# ENERGY CONSERVATION FOR NON-RESIDENTIAL BUILDINGS

Armstrong, Ontario

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# ENERGY CONSERVATION FOR NON-RESIDENTIAL BUILDINGS

## Armstrong, Ontario

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Armstrong Area Chamber of Commerce

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With a contribution from:

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# 1. EXECUTIVE SUMMARY

This project was undertaken for the Armstrong Area Chamber of Commerce by Shelter Construction & Development Ltd. and Martin Associates Architects, with funds provided under Phase 1 of the Remote Communities Demonstration Program by Energy, Mines & Resources Canada. The purpose of the study was to assess the potential of non-residential buildings in the Town to accept energy conservation improvements designed to save fuel oil for space heating.

Armstrong, Ontario is a small community of 126 households with a population of 800, and is located approximately 250 km north of Thunder Bay. The Town is situated on the CN transcontinental rail line and is served by Highway 527.

Twenty non-residential buildings in Armstrong were assessed initially to determine their energy conservation potential. This initial sample represented all of the major building types in the community: hotel, multiple accommodation, commercial/retail, assembly, and public/government. From this list, four buildings: the District School Board Office, Armstrong Public School, the Royal Canadian Legion Hall, and J & J Hardware store, were selected for detailed analysis, using the National Research Council HOTCAN computer program for calculating building heat loss.

The buildings were photographed and measured, and subjected to door fan (air infiltration) and furnace efficiency tests where feasible. A set of possible improvements to the heating system or building components (roof, walls, windows, sources of air infiltration, etc.) was developed and costed for each building. Computer runs were done for each building to determine the resultant energy savings from introducing improvements one at a time. The improvements were costed and then ranked in approximate order of their cost effectiveness, for each building.

The general conclusions of the study are that energy conservation measures which are both feasible and cost-effective can be undertaken for each of the

candidate buildings. Energy savings of 60% or higher can be achieved with measures having payback periods of about 5 years or less. Although the rankings of recommended improvements vary with each building, a general ranking of suggested measures, in order of their cost-effectiveness, emerged as follows:

- furnace tune-up and improvement
- reductions in air infiltration: weatherstripping, caulking, double-glazing, and related measures
- roof insulation (batts)
- wall insulation (batts).

Measures which were usually not cost-effective included rigid insulation applied to the roof or walls, insulated window shutters, and basement floor insulation.

In Armstrong, the results of the analysis suggest that as much as $140,000 or 36% of the community's fuel oil bill for space heating, could be saved annually, if every feasible non-residential building was upgraded to optimum levels. The capital costs for these improvements would range from $450,000 to $700,000. Local labour would represent approximately 40% of these costs, providing 10 to 20 man-years of employment.

The results of this study are felt to be applicable to other remote Ontario communities. However, detailed analysis would be required in each individual case, to account for intra-community variations in building construction and condition; as well as labour, fuel, transportation, and material costs; and to prepare an in-depth improvement program responsive to the needs of individual buildings and users.

# ETUDE DES POSSIBILITES D'ECONOMIES D'ENERGIE DANS DES BATIMENTS NON RESIDENTIELS A ARMSTRONG (ONT.)

## Résumé

Ce rapport rend compte d'une étude exécutée par les firmes Shelter Construction & Development Ltd. et Martin Associates Architects à la demande de la chambre de commerce de la région d'Armstrong. Financée par la phase I du Programme de démonstration dans les collectivités éloignées du ministère de l'Energie, des Mines et des Ressources du Canada, l'étude avait pour but d'évaluer les possibilités d'amélioration des bâtiments non résidentiels de la ville d'Armstrong afin de réduire la consommation de mazout nécessaire au chauffage des locaux.

La ville d'Armstrong est une petite localité de l'Ontario qui compte 126 ménages et une population de 800 habitants et qui est située à environ 250 km au nord de Thunder Bay. Elle est traversée par la voie transcontinentale du CN, et on peut s'y rendre par l'autoroute 527.

Les auteurs de l'étude ont commencé par examiner une vingtaine de bâtiments non résidentiels de la ville pour en évaluer les possibilités d'économies d'énergie. Tous les principaux types de bâtiments étaient représentés dans ce premier échantillon: hôtels, habitations à logements multiples, commerces/détaillants, salles de réunion et édifices publics/gouvernementaux. Les auteurs de l'étude ont retenu quatre bâtiments (le bureau de la commission scolaire régionale, l'école publique d'Armstrong, la salle de la Légion royale canadienne et le magasin J & J Hardware) en vue de les soumettre à une analyse détaillée à l'aide du logiciel HOTCAN qui a été mis au point par le Conseil national de recherches du Canada et qui sert à calculer les pertes de chaleur des bâtiments.

Les bâtiments ont été photographiés et mesurés; on y a effectué des essais d'infiltration d'air et mesuré le rendement des calorifères. Pour chaque bâtiment, les auteurs ont dressé une liste des mesures susceptibles d'améliorer le système de chauffage ou certaines parties du bâtiment (toit, murs, fenêtres, sources d'infiltration d'air, etc.) et en ont établie le coût. A l'aide du programme d'ordinateur, ils ont calculé les économies d'énergie pouvant résulter de chacune des améliorations et les ont classées par ordre approximatif de rentabilité.

Les auteurs de l'étude concluent qu'il est à la fois possible et payant de mettre en oeuvre des mesures d'économies d'énergie dans chacun des bâtiments analysés. Dans certains cas, on parvient à des économies de 60 % à l'aide de mesures dont le coût peut être amorti en 5 ans ou moins. Même si le classement des améliorations recommandées par ordre de rentabilité varie d'un bâtiment à l'autre, une certaine tendance générale se dégage:

- mise au point et amélioration du calorifère
- réduction des infiltrations d'air: pose de coupe-froid, calfeutrage, double vitrage et mesures connexes
- isolation du toit (isolant en vrac)
- isolation des murs (isolant en vrac)

La pose d'isolants rigides dans le plafond ou dans les murs, l'installation de volets isolants et l'isolation du sous-sol ne s'avèrent pas rentables en règle générale.

A Armstrong, les résultats de l'analyse démontrent qu'il serait possible d'économiser 140 000 $ par année, soit 36 % de ce que l'ensemble de la collectivité paie en mazout pour le chauffage des locaux, si tous les bâtiments non résidentiels étaient améliorés de façon optimale. Le coût en capital de ces améliorations se situerait entre 450 000 $ et 700 000 $. La main-d'oeuvre locale, estimée à 10-20 années-personnes, représenterait approximativement 40 % de ces coûts.

On croit que les résultats de cette étude valent également pour d'autres collectivités éloignées de l'Ontario. Toutefois, il faudrait procéder à une analyse détaillée dans chaque cas, pour tenir compte des variations dans la construction des bâtiments et les conditions locales, ainsi que dans les coûts de la main-d'oeuvre, du combustible, du transport et du matériel, et aussi pour mettre sur pied un programme d'amélioration approfondi, bien adapté aux besoins de chaque bâtiment et de chaque utilisateur.

# 2.0 INTRODUCTION

## 2.1 Background

Armstrong, Ontario is a small white/native community of 126 households with a population of 800, and is located approximately 250 km north of Thunder Bay. The Town is situated on the main CN transcontinental rail line, and is served by Highway 527, a partly paved and partly gravel road running north from the Trans Canada Highway at a point just east of Thunder Bay. (Full demographic and energy data for the Town are presented in Appendix A, following the main body of the report).

The focus on Armstrong came partly as a result of a 1983 project by the Ontario Ministry of Energy in which Shelter Construction and Martin Associates Architects, together with Solarctic and Retrospectors were retained to undertake the design and construction of 5 low energy homes in the Town. Some 30 houses were audited in the intial phase of that project (nearly 30% of the housing stock in the community), from which 5 were selected for retrofit and renovation. Virtually the entire range of existing housing types in the Town was assessed in this initial phase of the OME project.

The present study, undertaken for the Armstrong Area Chamber of Commerce, under the Remote Community Demonstration Program of Energy, Mines & Resources Canada, addresses energy conservation in the non-residential sector of Town, namely institutional and commercial buildings. There were several reasons for this approach:

(a) Between the two studies, there would be a virtually complete assessment of the energy conservation potential of all building types in the Town;

(b) While the greatest number of buildings in Armstrong (as in most towns) is residential, the smaller number of non-residential buildings uses oil for space heating in greater quantities, because housing is often totally or partly heated by wood. Therefore, greater reductions in oil space heating use may come from analysing and improving non-residential buildings.

(c) Most non-residential buildings are simple, one-storey structures and are readily retrofitted to improve energy consumption. Owners and managers of such buildings in Armstrong expressed an interest in the project and

in applying its results to reduce their oil heating bills.

(d) Energy conservation, like most technologies, tends to have a declining marginal return (that is, the first dollar invested saves more than the last dollar). However, it is still likely that energy conservation improvements will have one of the lowest ratios of dollars invested per dollars of oil saved, of any measures considered for displacing oil. In other words, energy conservation will represent one of the best economic returns over a wide range of levels of energy investment. Many remote community buildings are constructed to only moderate levels of insulation and air tightness, and relatively simple, low cost measures should have excellent payoffs, as well as wide applicability.

(e) A community generally has two ways to save on energy costs: 1) energy supply; lowering the cost of energy consumed, or 2) energy conservation; using less energy. Energy conservation measures have the advantages of being almost infinitely divisible, of being available to anyone in the community, and of being transferrable from community to community (because they are not dependent on a specific energy resource such as peak wind, running water, biomass, etc.). Because they are divisible, the costs for any individual installation can be small, although the sums expended in total may be large.

Therefore a study of community energy conservation potential was felt to be an important component in any comprehensive strategy to reduce dependence on oil in remote communities.

## 2.2 Report Format

The report follows the basic sequence by which the work was done in the study.

Chapter 3 lists the non-residential buildings surveyed in Armstrong, and the criteria by which four buildings were selected for detailed analysis. Also described are the door fan and furnace efficiency tests undertaken for three of these four buildings.

Chapter 4 describes the detailed analysis phase of the work; first, the process in general terms, and then, specific results for each candidate building: data (building statistics, plans, photos), energy conservation improvements and costs, analysis of heating energy savings for each improvement together with simple payback period, and resulting recommendations.

Chapter 5 outlines general recommendations of the project, both in terms of a process to be followed to determine a building's potential for energy conservation, and also in terms of specific measures which seemed to be cost-effective for the buildings in this study.

Chapter 6 discusses the community impacts of energy conservation. One of these is an estimate of the overall effect on the community's oil use for space heating if all feasible non-residential buildings were to be upgraded to optimum levels, together with the capital costs involved. The other impact discussed is the local employment which would be generated if such an upgrading program were to be undertaken in Armstrong.

Chapter 7 concludes with a discussion of the applicability of the study process and findings to other remote Ontario communities.

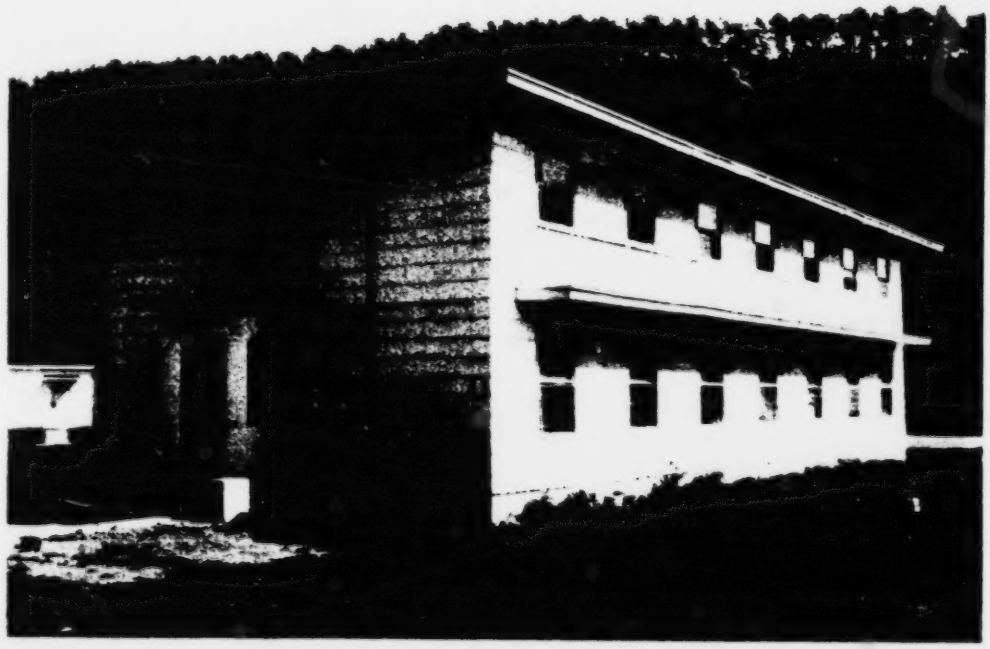
## 3. PRELIMINARY SURVEY OF NON-RESIDENTIAL BUILDINGS

### 3.1 List of Buildings

A list was made of nearly all the non-residential buildings in the community. Each building was measured, and a data sheet and schematic plans (see sample) were prepared. A visual record including photos was also made. Owners and managers were contacted to determine if the building used oil, if recent fuel records were available, and if they were interested in participating in the project. In several cases, fuel records were not immediately available, or were consolidated within a group of buildings, which would have required further analysis to identify the individual fuel use. This difficulty was temporary in most cases, and was not generally a deterrent to selection of the building for further analysis.

| Hotels | Oil Use | 1982 Fuel Bill |
|---|---|---|
| King George Hotel (see photo) | yes | $7,000+ |
| D & L Estates Hotel Building (see photo) | yes | $125,000 (complex) |
| **Multiple Accommodation** | | |
| D & L Estates Apartment Unit | yes | " " |
| CN Rail Crew Hostel | yes | $12,575 |
| MNR Staff Apartments | yes | not available separately |
| **Commercial/Retail** | | |
| J & J Hardware | yes | $4,510 |
| Wilderness Restaurant | yes | $3,000 |
| Shorty's Meats & Groceries | | not interested |
| Laybourne Esso Distributorship | yes | not available |
| Laybourne Garage | yes | $2,900 |
| **Assembly** | | |
| CN Station (see photo) | yes | not available |
| Catholic Church (see photo) | yes | not available immediately |
| Royal Canadian Legion | yes | periodic use |

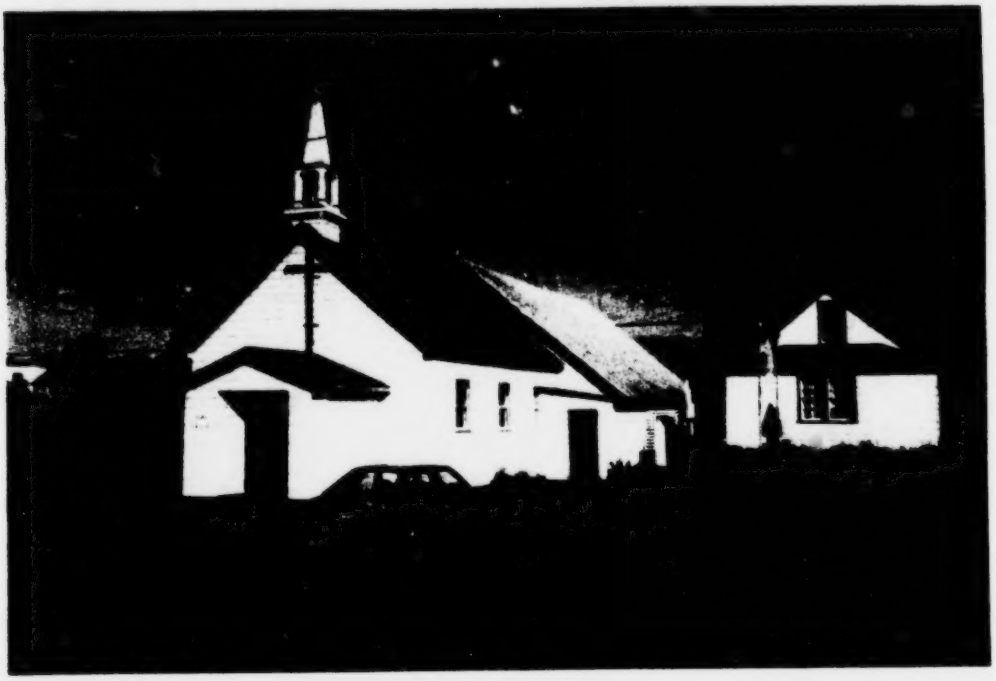
King George Hotel, King Street



D & L Estates, Apartment/Hotel Unit

CN Station

Lions Club & Curling Rink



Catholic Church

Post Office

SAMPLE SURVEY SHEET

Remote Community Demonstration Program; Armstrong, Ont.

Non Residential Building Survey; Aug.5-10,1983 SURVEY No. 5.1

**Identification:** Owner: D & L Estates. (Jack Lundstrom)
Address: P.O. Box 117, Armstrong
Phone: 583-2061

**Dimensions:** Floor Area $M^2$ Ground: 176 Second: 173 Basement: 0
Heated Volume $M^3$ 951
Above grade envelope area $M^2$ Walls: 310 Ceiling: 171
Below grade wall envelope area $M^2$ —

**Construction type and insulation:** $M^2$ and RSI
Year of Construction: 1950-51
No.Stories: 2
Walls: 310
Floor: 171
Ceiling: 171
Below Grade: 0
Windows: 44
Vestibules: 1 @ 14 $M^2$
Doors: Solid; 0 Glazed: 3

**Construction Details:**
Roof: trusses w. 2"x6" ceiling joist, R20 insulation
Soffits: ~~—~~ plywood
Vents: 0 vents in soffits @ 0.08 $M^2$ (0.64 $M^2$), Also vented in gables.
Chimney: metal - added to exterior
Exterior Siding: Asbestos
Interior Panelling: Gyproc.
Interior Ceiling: Gyproc ?
Structural Problems: No
Window quality: Some broken windows & frames.
South facing Windows? 4
Wind Shielding and site: None

**Heating System:**
Furnace: 199,100 BTU/hr. Fuel used: Oil
Other: Propane also - 27,723.15/yr. TOTAL complex
Comments: Hot water runs continuously - no shut off - Needs repair.
Fuel Bill: July '82 - July '83 - $125,856.26 for total complex.
Servicing of System? Once a year? No Rarely? yes.
Exhaust Fan: No.

**Problems:** Drafts: yes -
Cold in Winter? yes.
Control of temp: Oil burner running continuously - Furnace room 100°.
Freezing Pipes? no.

**Previous Work Done:**
Additions: No
Re-Insulation: 1982 - added ceiling insulation
Weatherstripping: none.
Repairs: many broken windows.

| | Oil Use | 1982 Fuel Bill |
|---|---|---|
| Lions Club & Curling Rink (see photo) | propane | periodic use |
| Ion Theatre | - | no winter heating |
| **Public/Government** | | |
| District School Board Office | yes | $2,200 |
| Armstrong Public School: Main Building | yes | $10,400 |
| Portables | electric | not available |
| OPP Building | yes | not available immediately |
| MNR Office | yes | not available separately |
| Post Office (see photo) | yes | $851 |

### 3.2 Criteria for Selection for Further Analysis

Because project resources were limited, it was decided to concentrate the "in-depth" analysis on a small number (four) of buildings representative of the rest. Several criteria were suggested by the consultant and EMR staff to select these buildings:

1. The existence of similar buildings (construction type or use) in other remote communities.
2. Sufficient data (particularly fuel records) available for detailed analysis; ability to collect data (for example, conduct a door fan test) - useful but not essential.
3. Building condition: able to be renovated, reasonable present condition and life expectancy for the structure.
4. Business or use operating as a going concern (that is, expectation that the owner could commit funds to renovation).
5. Representation of a variety of building types and uses in the sample.
6. Jurisdiction and responsibility for operation: would the owner/operator make use of the information, and be willing to consider renovation?
7. Year-round use (if not at the present time, at least an expectation that renovation would enable the building to be used in winter).
8. Space heating primarily by oil.

## 3.3 Selection Process

A number of the twenty buildings in the initial sample were eliminated on relatively straightforward grounds:

1. Buildings recently constructed or renovated, with relatively high levels of insulation and/or air tightness:
   - OPP Building
   - MNR Offices and staff apartments
   - Post Office.
2. Lack of Interest on the part of the Owner/Operator:
   - Shorty's Meats & Groceries
3. Not heated in winter:
   - Ion Theatre
4. Continued operation economically doubtful or to be replaced:
   - King George Hotel
   - CN Old Station
5. Not heated with oil:
   - School portable classrooms
   - Lions Club and Curling Rink.

The remaining buildings were then categorized as follows:

First Priority: no difficulties in analysis or retrofitting:

| | |
|---|---|
| • Public/Government | District School Board Office |
| • Assembly | Royal Canadian Legion |
| • Commercial | J & J Hardware. |

Second Priority: some difficulties (but not insurmountable) in analysis or retrofitting:

| | |
|---|---|
| • Public/Government | Armstrong Public School |
| • Accommodation | D & L Estates Hotel/Apartment |
| • Commercial | Wilderness Restaurant |

Remainder: duplicate building types, intermittent use, unrepresentative type, other constraints.

The three "First Priority" buildings: District School Board Office, Royal Canadian Legion, and J & J Hardware, were selected for detailed analysis. Two "Second Priority" buildings, the Armstrong Public School and Wilderness Restaurant, were also selected. The Wilderness Restaurant had to be dropped because of the complexity of the analysis (involving two uses: restaurant and apartment within the same structure, two heating sources, and substantial unmeasurable heat gains from the kitchen and restaurant customers, as well as heat losses). The large floor area and volume of the Armstrong Public School made it difficult to analyse within the bounds of the HOTCAN computer program, but these problems were subsequently overcome.

# 4. DETAILED ANALYSIS AND RESULTS

## 4.1 Process

A 6-step procedure was followed for each building analysed in detail:

1. On-Site Tests: where feasible, door fan tests to measure natural ventilation rate, and furnace efficiency tests were conducted on the candidate building to provide empirical values for the HOTCAN computer program. These tests are described in more detail in section 4.2.

   In this study, these tests were not done until partway through the analysis process because of scheduling problems, but ideally, they would constitute the first step.

2. Initial Computer Run: the areas and thermal resistances of the building's roof, walls, floor, window, and door components, and assumed or "real world" values for variables such as air infiltration rates are input to the HOTCAN program. (see Appendix B for a sample HOTCAN run). The results of the HOTCAN program were compared with 1982 heating costs based on confirmed bills. Ideally, heating bills should be collected for several years to derive an accurate historical average. For example, 1982 was an unusually mild year, and may have produced slightly distorted analysis results.

   The values of certain variables were adjusted on subsequent runs to bring the HOTCAN predicted heating costs closer to actual heating costs. The set of input values which provides the best prediction is termed a "calibrated" run.

3. Analysis of the calibrated HOTCAN run to determine which building components or values lose the greatest amount of heat. (see Appendix B - HOTCAN run). The major items were usually the following:

   - air infiltration
   - roof
   - walls above grade
   - basement floor
   - windows

4. Costing of feasible improvements to each component, concentrating initially on those which appear to lose the most heat. These are ranked in order of apparent cost-effectiveness.

5. Subsequent computer runs, changing each component in its order of priority, one at a time, so that the contribution of each change can be identified. This incremental analysis also enables the owner to determine when to stop making improvements to his building, as they become less and less cost-effective (since the building uses less energy as it becomes successively more efficient).

6. A cost-effectiveness analysis which compares the costs of the measure or change with the dollar savings in oil. The primary measure used is the ratio of dollars invested to dollars saved, or "simple payback" in years. The simple payback measure assumes that fuel cost inflation and interest rates are approximately the same.

The apparent cost effectiveness of energy conservation measures will be different for each owner, depending on several factors such as his financial situation, condition and life expectancy of the building, and how long he expects the use to continue. Some "rule of thumb" classifications may be useful:

| Payback | Classification |
|---|---|
| Under 2 years | excellent |
| 2 - 5 years | good |
| 5 - 10 years | fair |
| 10 + years | poor. |

A capital investment paid back in two years of energy savings would be attractive to nearly all building owners. The payback of an investment in 2 to 5 years would also be attractive to most owners unless they are planning to replace the building or use within that time. A 5 to 10 year payback would be reasonable to some owners, but possibly not to others, based on their investment criteria, and other factors such as building condition. An investment with a payback period longer than 10 years is probably unlikely unless the owner has low investment expectations or is committed to ongoing maintenance or use of the structure for another 15 to 20 years. This is a long period to predict that many northern buildings of simple wood construction will be in use.

## 4.2 On-Site Tests

Where feasible, several on-site tests were done on the selected buildings, to provide "real world" inputs to the HOTCAN computer program and to identify major areas of air infiltration into each building. In one of these tests, a door fan is mounted in one of the exterior doors of the building and induces a partial vacuum within it. From the resulting pressure drop, a natural ventilation rate in air changes per hour (ach) can be calculated. While the fan is operating, a smoke pencil is used to locate the major sources of air leakage into the building. The door fan test is limited to fairly small and compact buildings, thus larger or complex buildings such as tha Armstrong Public School or Wilderness Restaurant could not be assessed in this manner.

The other major test carried out by Retrospectors Inc. (see Appendix C) was a furnace efficiency test, in the same buildings as the door fan tests. This relates a number of factors such as oil consumption rate, stack temperature, furnace condition, flue input and output temperatures, to estimate the furnace steady-state efficiency; i.e. the ratio of the thermal energy produced by the furnace to the thermal energy potentially contained within the fuel burned by the furnace.

### 4.21 Test Results

(a) District School Board Office

Door Fan Test:

- Equivalent Leakage Area (ELA) 0.2 $m^2$
- Predicted (natural) infiltration: 1.07 air changes per hour (ach)

Most of the infiltration was found to occur through the heating ducts which penetrate the floor from the main floor furnaces, run through the unheated crawl space to penetrate the floor again at the points of distribution. Other major infiltration points include the ceiling where the trailer sections join, electrical outlets, wiring and piping penetrations through the floors, and front doors.

Furnace Efficiency Test (estimate: 40 to 50%)
This test could not be carried out since the furnaces were located in spaces too small to allow equipment access. Furnace efficiencies were estimated by Retrospectors as poor, in the range of 40 to 50%.

(b) Royal Canadian Legion Hall

Door Fan Test

- ELA = 0.313 $m^2$
- Infiltration = 0.925 ach

Most of the infiltration was found to occur through two washroom ventilation fans.

Furnace Efficiency Test: 75%
The furnace is fairly new, and running smoothly, probably as well as possible. The fresh air intake is leaky, bringing in cold air.

(c) J & J Hardware

Door Fan Test

- ELA = 0.345 $m^2$
- Infiltration = 0.32 ach.

Infiltration was found to occur through the back and front doors, ceiling tiles, and furnace ductwork. The fresh air intake to the furnace should be removed.

Furnace Efficiency Test: 75%
This value is resonable, but the runace is running "smoky". The heat exchanger should be cleaned.

(d) Armstrong Public School

Door Fan Test: not done because of the large volume of the building.

Furnace Efficiency Test: not done as well. How do you know what to do?

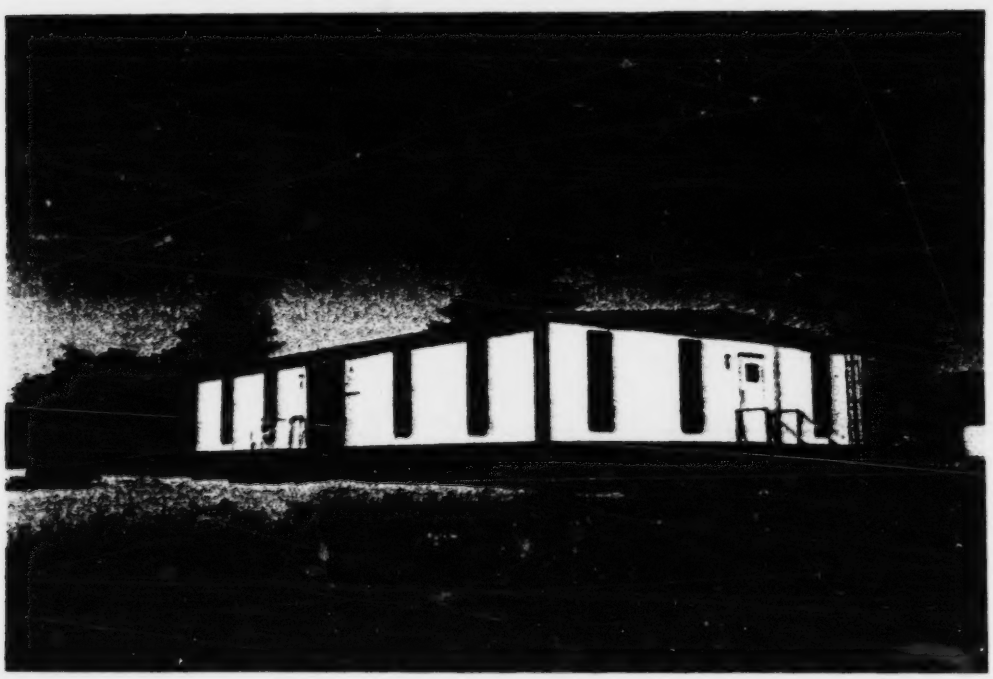
## 4.3 Buildings

### 4.31 District School Board Office

The School Board Office is a one-storey building, 186 $m^2$ in floor area, made up of three pre-manufactured, linked trailers, trucked to the site and set on block foundations. The trailers are simple wood construction, with painted metal exterior siding. The building is fairly well insulated, with double-glazed windows, however, the heating bills are still high, considering the size of the building.

The door fan tests indicated high infiltration rates (greater than 1.0 air changes per hour) through the heating ducts, outlets, and all penetrations of the floor structure. Infiltration also occurs in the ceiling space where the trailer units join.

The building has two furnaces, apparently in poor running order (operating at an estimated steady state efficiency of no greater than 50%).



South West Corner View

**Remote Community Demonstration Program; Armstrong, Ont.**

**Non Residential Building Survey; Aug.5-10,1983** SURVEY No. 2-1

**Identification:** Owner: Board of Education (Northern DSA) SCHOOL BOARD OFFICE
Address: P.O. Box 98, Armstrong, POT 1A0
Phone: 583-2888

**Dimensions:** Floor Area $M^2$ Ground: 186 Second: 0 Basement: 0.
Heated Volume $M^3$ 454.
Above grade envelope area $M^2$ Walls: 136 Ceiling: 186.
Below grade wall envelope area $M^2$ 0

**Construction type and insulation:** $M^2$ and RSI
Year of Construction: 1975?
No.Stories: 1
Walls: 2" x 4" studs, probably R12. RSI 2.11.
Floor: 2" x 6" wood joists on open-web steel joists., R 12, RSI 2.11
Ceiling: 2" x 6" ceiling joists, probably 2" insulation R8, RSI 1.40.
Below Grade: nothing, duct ducts travel in crawl space under floor.
Windows; 12.9 $m^2$
Vestibules: 1 with glass doors
Doors: Solid; 2 with small windows Glazed: Pivoting glass (3.66 $M^2$)

**Construction Details:**
Roof: 2 x 6" bottom member, trusses. R8 insul.
Soffits: None
Vents: Vents in gables.
Chimney: Metal
Exterior Siding: Alum siding
Interior Panelling: Prefinished Ply
Interior Ceiling: Prefinished
Structural Problems: NO
Window quality: fair
South facing Windows? 3 (3.09 $M^2$)
Wind Shielding and site: none.

**Heating System:**
Furnace: Intertherm MAC 200, 78,000 BTU/hr Fuel used: #2 oil.
Other: 45 cc/minute.
Comments: 0.72 gallons/hr.
Fuel Bill: Jan - Aug. 83. $4662.06
Servicing of System? Once a year? NO Rarely? Not often
Exhaust Fan: NO

**Problems:**
Drafts: NO
Cold in Winter? NO - Furnace Run continuously.
Control of temp: OK - small area.
Freezing Pipes? NO.

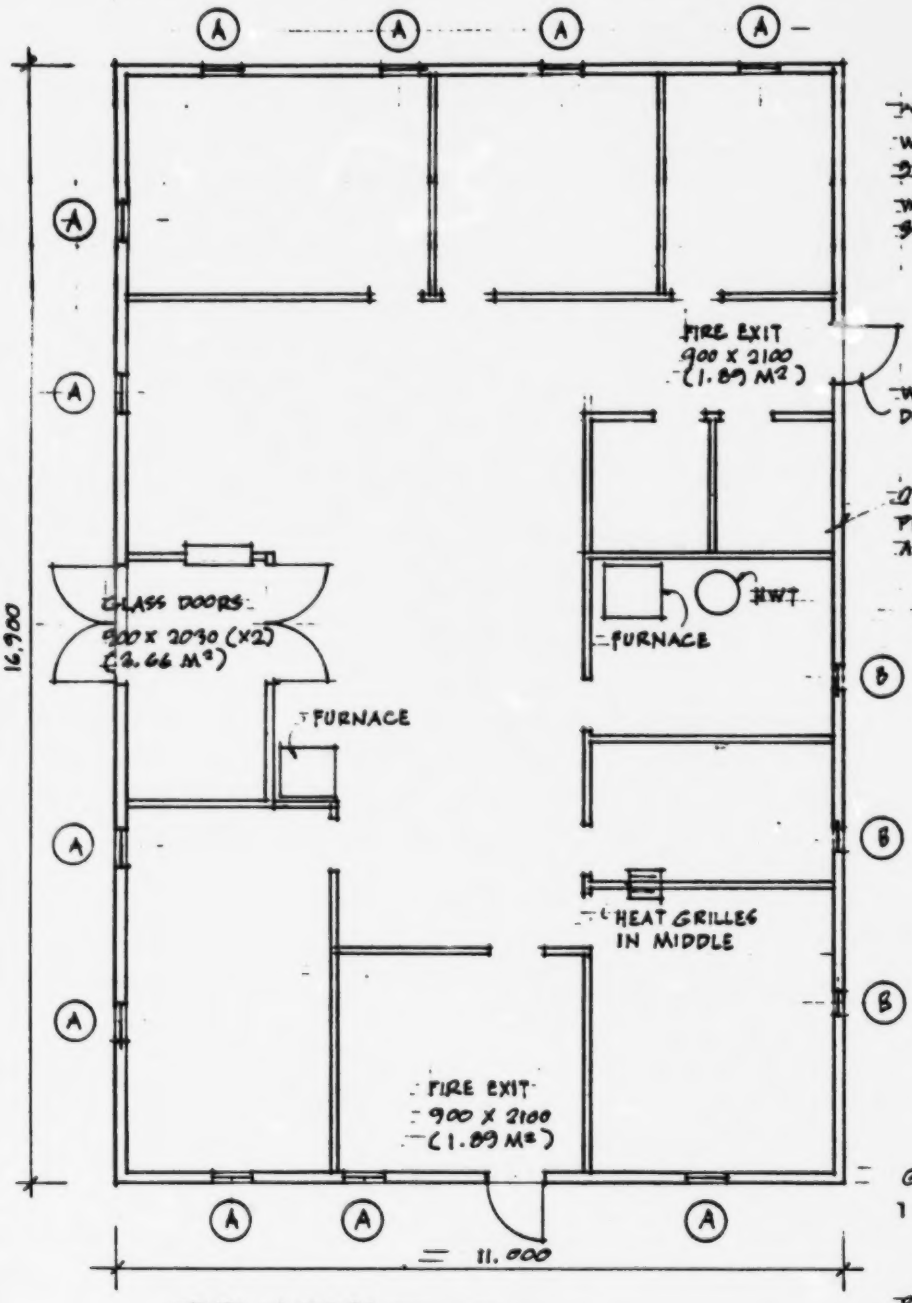
**Previous Work Done:**
Additions: None
Re-Insulation: NO
Weatherstripping: NO - Needs repair
Repairs: - Some perimeter insulation under trace.

Check if vented?

25

# DISTRICT SCHOOL BOARD OFFICE.

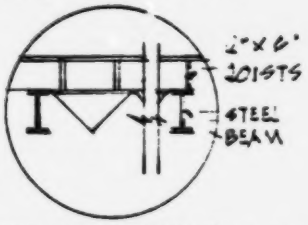




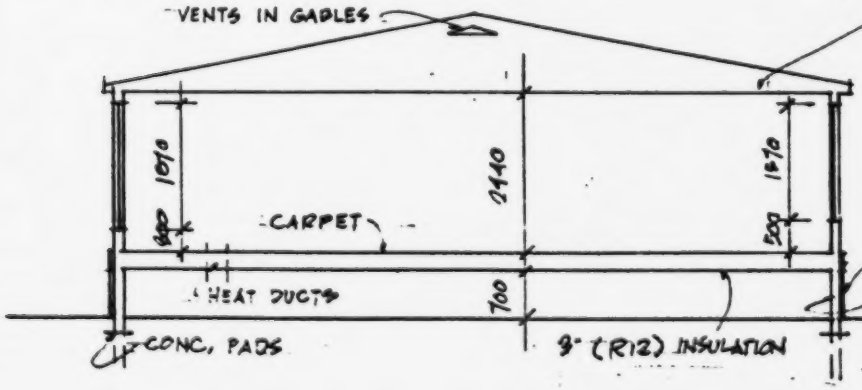

NOTE
WINDOW 'A':
930 x 1870 (1.03 M²)
WINDOW 'B':
940 x 1570 (0.59 M²)

GROUND FLOOR PLAN.
1 - 100

FLOOR DETAIL.




DUCTS RUN BETWEEN 2"x6"
WOOD JOISTS, 3" (R12)
INSULATION BETWEEN ALSO.




SECTION 1 - 100

Table of Proposed Changes and Costs

| | | | Total Costs |
|---|---|---|---|
| 1(a) | Furnace Tune-up (2) | | |
| | Tune-up (2) | $280 | |
| | Control Dampers (2) | $380 | |
| | New Burners (2) | $1,200 | $1,860 |
| 1(b) | New Furnace + 1 Tune-up | | |
| | New furnace (1) | $1,800 | |
| | Tune-up (1) | 140 | |
| | Control Damper (1) | 190 | |
| | Burner | 600 | $2,730 |
| 2. | Reduce Air Infiltration | | |
| | Weatherstrip door | 120 | |
| | Shrink wrap windows | 280 | |
| | Caulk baseboards | 150 | $550 |
| 3. | Insulate Roof | | |
| | Add fiberglass batts to ceiling space; R40 in centre, R20 at edges, for an R30 average overall | | $1,450 |
| 4. | Insulate Floor | | |
| | Batt insulation, strapping to hold insulation in; wrap ductwork | | $1,900 |
| 5. | Insulate Walls | | |
| | Take off interior panelling; add R12 batts, 25 mm styrofoam, re-apply panelling, re-trim | | $1,750 |
| 6. | Add Insulated Panels to Some Windows | | |
| | R10 rigid insulation covered panels to one half the windows (6.5 $m^2$) | | $400 |

Results

| Changes | Predicted Heating Costs | Incremental Heating Savings | Capital Cost of Change | Simple Payback Period |
|---|---|---|---|---|
| 0. Existing Building | $2,200 (1982) | | | |
| 1(a) Furnace tune-ups to 70% seasonal efficiency | $1,570 | $630 | $1,860 | 3 years |
| OR | | | | |
| 1(b) 1 new furnace + 1 tune-up, temp. setback | $1,250 | $950 | $2,730 | 2.9 years |
| Therefore, alternative 1(b) is slightly preferred for implementation. | | | | |
| 2. Reduce air infiltration | $950 | $300 | $550 | 1.8 years |
| 3. Add R30 to ceiling insulation | $715 | $235 | $1,475 | 6.3 years |
| 4. Floor insulation | $530 | $185 | $1,900 | 10.3 years |
| 5. Add R6 wall insulation | $500 | $30 | $1,750 | 58.3 years |
| 6. R10 window shutters | $470 | $30 | $400 | 13.3 years |

Recommendations

Furnace tune-ups (or replacement) and reductions in air infiltration are high-priority measures.

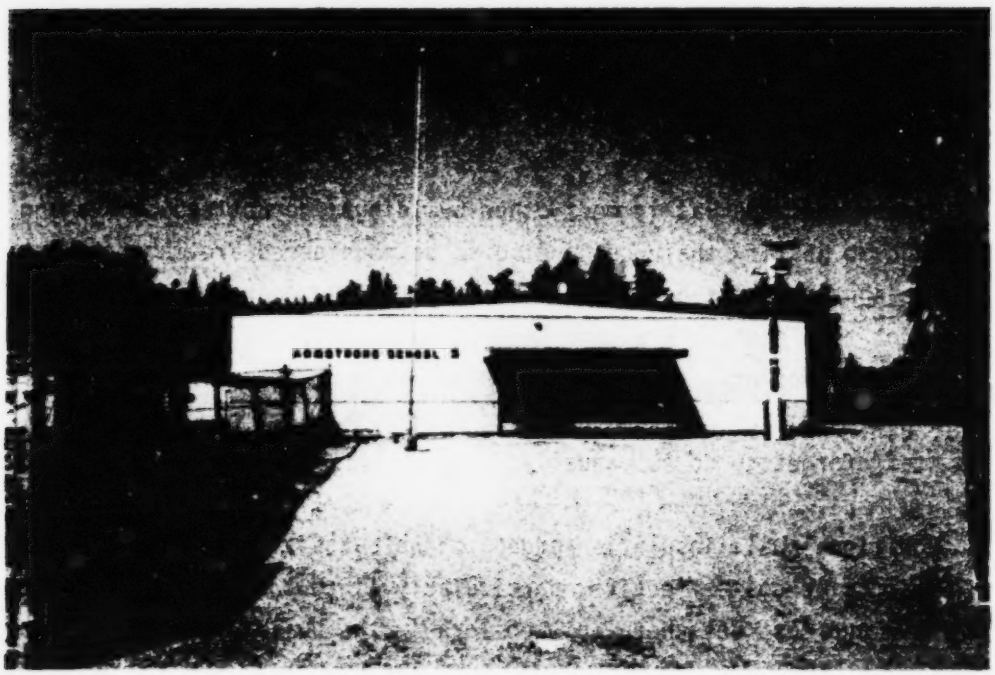
Roof insulation, with a payback period of slightly more than 6 years is marginally cost-effective depending on investment criteria. Floor insulation, with a payback of 10 years does not appear to be economical at first glance, but is probably useful to reduce air infiltration through the leaky duct work in the crawl space (since the ducts can be wrapped at the same time) and to insulate an unheated crawl space, which will be nearly as cold as the exterior. Work from under the crawl space can be done while the building is in use.

Window shutters, as in most other buildings, do not reduce heating costs enough to justify their cost. Also to be considered are maintenance issues, since the shutters must be systematically installed when staff leave, to reduce night time heat losses, and removed daily to allow passive solar gain. The installation of a setback thermostat would be useful in the same regard, since it can be programmed to set back night time temperatures, even if staff forget to do so manually.

Additional wall insulation added to the batts already in place does not appear to be cost-effective, particularly since installation is labour-intensive and must be scheduled when work in the building will not be affected.

## 4.32 Armstrong Public School

The Armstrong Public School is a handsome one-storey building constructed with glu-lam wood roof beams, exposed on the interior. The building is long (53.6 m) and oriented in a north-south direction. The walls are well insulated, but there are also extensive window areas on the east and west faces of the school. Heating bills are very high, exceeding $11,000 per year. On the positive side, the building is well maintained, all entrances have vestibules, and the furnaces are regularly serviced.



Main Entrance: South Side

Door fan tests could not be done because the volume of the school is so large that depressurization was impossible with the equipment available. The furnaces were also not tested because of scheduling problems, but based on the other tests and the school's good maintenance record, steady-state efficiencies are probably in the range of 75%, resulting in seasonal efficiencies of approximately 55 to 60%.

Remote Community Demonstration Program; Armstrong, Ont.

Non Residential Building Survey; Aug.5-10,1983 SURVEY No. 3.1

**Identification:** Owner: Armstrong School
Address: P.O Box 98 Armstrong, Ont. POT 1A0
Phone: 583-2076

**Dimensions:** Floor Area $M^2$ Ground: 884 Second: 0 Basement: 0
Heated Volume $M^3$ 3184
Above grade envelope area $M^2$ Walls: 483 Ceiling: 911.
Below grade wall envelope area $M^2$ 0

**Construction type and insulation:** $M^2$ and RSI
Year of Construction:
No.Stories: 1
Walls: 2"x6" studs, insulation unknown.
Floor: slab on grade
Ceiling: Glu-lam beams, purlins, decking (2"x6") insul above?
Below Grade: nothing
Windows; 121,3 $M^2$, 2X.
Vestibules: 3 at all entrances.
Doors: Solid; 0 Glazed: 5 with 600 x 1500 glass.

**Construction Details:**
Roof: Glu-lam beams, purlins, 2"x6" deck
Soffits: 0
Vents: 0
Chimney: metal
Exterior Siding: 1/4" Asbestos Board.
Interior Panelling: Gyproc
Interior Ceiling: Wood Decking
Structural Problems: None
Window quality: Fine -
South facing Windows? 3 (3.60 $M^2$)
Wind Shielding and site: tall conifers on north side

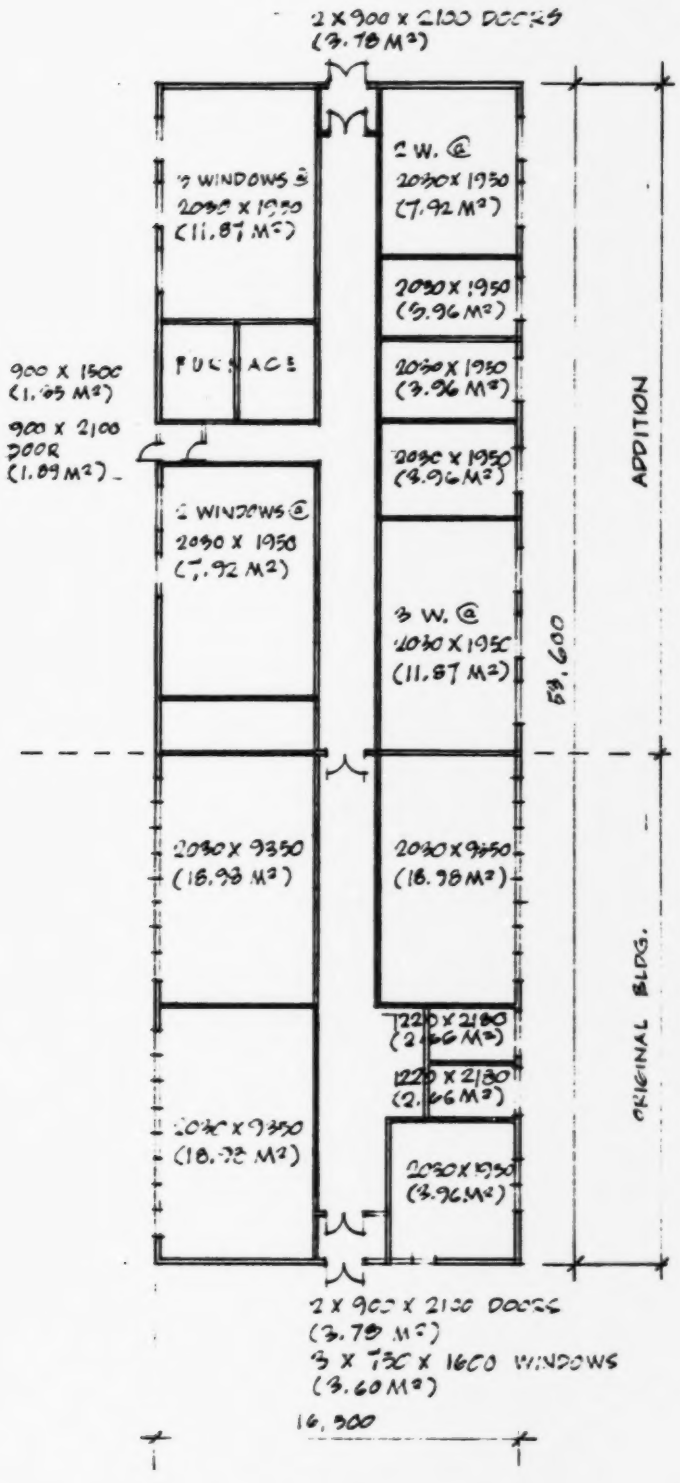
**Heating System:**
Furnace: 4 @ 250,000 BTU/hr. (Row 2 Water Corp.) Fuel used: Oil
Other: Hot water by propane.
Comments: 2.25 gal/hr.
Fuel Bill: 1982 - 30.84/l - $10,372.39; Jan-July 31 83 - [illegible]
Servicing of System? Once a year? Yes ~~Regularly~~? 53.2 - $93.
Exhaust Fan: washrooms

**Problems:** Drafts: No - Vestibules
Cold in Winter? No
Control of temp:
Freezing Pipes? No

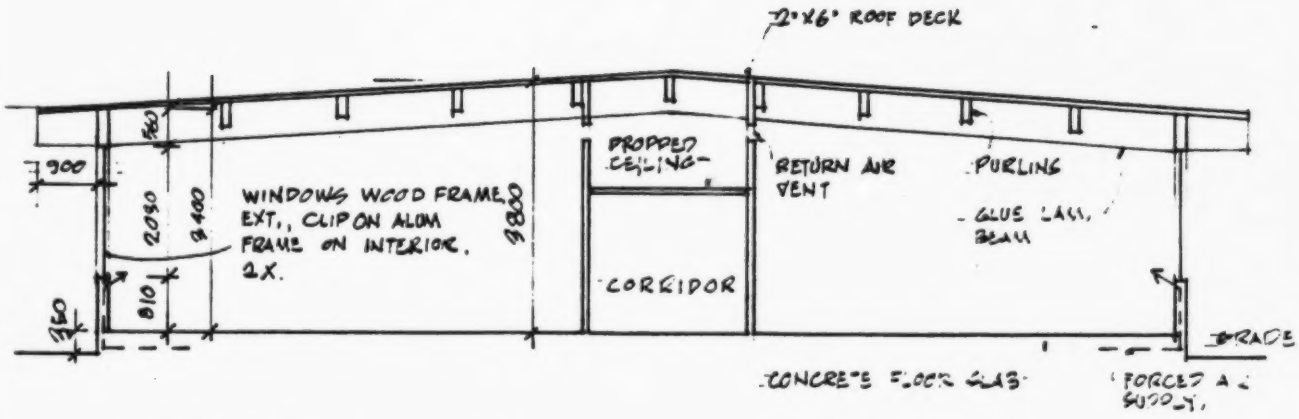
**Previous Work Done:**
Additions: None
Re-Insulation:
Weatherstripping:
Repairs:

21

# ARMSTRONG SCHOOL

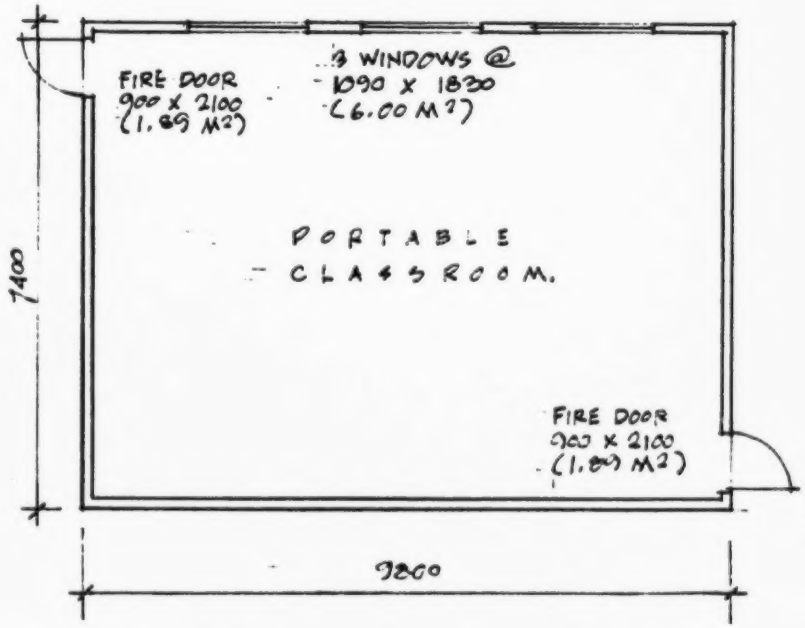



FLOOR PLAN 1:300




SECTION 1 - 100
(MAIN BLDG.)

~NOTE~
2" x 6" WALLS
GYPROC INSIDE
1/4" ASSESTOS BOARD OUTSIDE




FLOOR PLAN
1 - 100.

Table of Proposed Changes and Costs

| | Total Costs |
|---|---|
| 1(a) Furnace Tune-up<br>cleaning, maintenance, tune-up (4) | $1,000 to $2,000 |
| 1(b) Furnace Major Overhaul (4)<br>cleaning, maintenance, set-back thermostats, retention head burners (4) to improve operating efficiencies | $5,000 |
| 2. Reduce Air Infiltration<br>door weatherstripping, gasket all opening windows, caulking windows, shrink-wrap non-operable windows | $1,000 |
| 3. Reduce Window Area by 50%<br>Replace ½ of the windows with R12 wall section (wood frame, asbestos cement exterior siding, batt insulation, vapour barrier, painted gypsum wallboard) | $3,000 |
| 4. Insulated Edge Skirt<br>R10 rigid insulation + protection board, excavated to 600 mm below grade | $2,000 |
| 5. Roof Insulation<br>Two alternatives:<br>(a) 50 mm urethane (R14) foamed on roof (exterior) + protective coating) - acts also as a new roof surface | $28,500 |
| (b) R40 batt insulation between glu-lam beams (interior) + structure, vapour barrier, gypsum wallboard ceiling | $17,000 |
| 6. Floor Insulation<br>50 mm styrofoam on wood strapping, with new plywood and carpet | $28,000 |

Results

| Changes | Predicted Heating Costs | Incremental Heating Savings | Capital Cost of Change | Simple Payback Period |
|---|---|---|---|---|
| 0. Existing Building | $11,416 (1982) | | | |
| 1(a) Furnace tune-ups | 8,150 | $3,200 | $1,000 - $2,000 | 4 - 7 months |
| 1(b) Furnace Major overhauls + temp. setback | 6,000 | $5,400 | $5,000 | 11 months |

Note: Estimates of furnace improvments are possibly inaccurate since furnace tests were not actually carried out - see discussion in Section 6.1

| | | | | |
|---|---|---|---|---|
| 2. Reduce air infiltration (assuming 1(b) implemented) | 3,750 | $2,250 | $1,000 | 5½ months |
| 3. Reduce window area by 50% | 2,775 | $975 | $2,950 | 3 years |
| 4. Edge Skirt | Not cost-effective | | | |
| 5. Roof Insulation | | | | |
| (a) R14 rigid insulation (exterior) | 1,050 | $1,725 | $28,500 | 16.5 years |
| (b) R40 batts (interior) | 475 | $2,300 | $17,000 | 7.4 years |

Therefore, alternative 5(b) preferred for implementation

| | | | | |
|---|---|---|---|---|
| 6. Floor Insulation (assuming 5(b)) | 375 | $100 | $28,000 | 285 years! |

Recommendations

As with other structures, furnace improvements or overhaul (including night time temperature setback) and simple measures to reduce air infiltration (caulking, weatherstripping, gaskets, etc.) are cost-effective, with payback periods under 2 years.

Reducing the extensive window areas in the building and replacing them with insulated wall sections is also effective. Even this reduced window area should still provide sufficient daylight to the classrooms. Night window shutters may also be desirable for the remaining windows, if the maintenance problems discussed with the School Board Office can be overcome.

Batt insulation placed on the underside of the ceiling is desirable, but the increased ceiling thickness will reduce, if not eliminate altogether, the effect of exposed laminated wood beams. Exterior roof insulation is much more expensive than interior batts, and is only justifiable if the roof must be extensively repaired or replaced. In such a case, the foamed urethane and protective coating also act as a new roof surface.

Not effective for this building are the perimeter edge skirt and floor insulation options, both of which had little effect on heating bills.

By including improvements with a payback period under 7.4 years (allowing the roof batt insulation), an amazing 95% reduction in oil use is indicated by the analysis. Savings of $10,900 for an investment of $26,000 result in a simple payback in 2.4 years. Some allowances must be made for errors in the analysis, since the building did not fit the parameters of the HOTCAN program, and furnace tests were not carried out. Based on the results of the other buildings, it appears that reductions as high as 60 - 70% may still be feasible (see discussion in Section 6.1 Energy Savings). These reduced savings of $6,850 to $8,000 for the same investment of $26,000, still result in very acceptable paybacks of 3.25 to 3.8 years.

## 4.33 Royal Canadian Legion Hall

This is a high one-storey building with a high basement, 132 $m^2$ in ground floor area. There are vestibules are the front and rear entrances. The structure is wood frame, with asbestos cement siding. The windows are poor; some are broken and covered with plywood. Interior finishes are also poor.

The building used to function for meetings and gatherings only on demand, and was not continuously heated in the winter, therefore, annual fuel bills were not available for the analysis. Presently (winter of 1983-84) the building is being renovated so that it can be used as an office and training centre year-round.

The door fan test indicated that the greatest air infiltration occurs through two basement exhaust fans (apparently unprotected), as well as through the furnace intake duct (thereby lowering the temperature of heated air delivered to the hall).

Front Entrance, South Side

Remote Community Demonstration Program; Armstrong, Ont.

Non Residential Building Survey; Aug.5-10,1983 SURVEY No. 17.1

**Identification:** Owner: Bud Langtree, Royal Canadian Legion
Address: King Street c/o Nick Gurral, Thunder Bay
Phone: none call Thunder Bay 623-7796 623-6446 work

**Dimensions:** Floor Area $M^2$ Ground: 132 Second: 0 Basement: 115.
Heated Volume $M^3$ 421.
Above grade envelope area $M^2$ Walls: 151 Ceiling: 115
Below grade wall envelope area $M^2$ 0

**Construction type and insulation:** $M^2$ and RSI
Year of Construction:
No.Stories: 1
Walls: Probably 2" X 4" studs, insul unknown.
Floor: N 2" X 6" joists.
Ceiling: maybe R12?
Below Grade: basement w 3 windows (1.5 $M^2$) .1X.
Windows; 8.3 $M^2$ on main floor including 3 boarded up windows.
Vestibules: 2.
Doors: Solid; 2. Glazed: 0

**Construction Details:**
Roof: Truss- metal decking
Soffits: None
Vents: Vents in gables.
Chimney: metal chimney through bldg. roof.
Exterior Siding: Asbestos
Interior Panelling: Prefinished poly.
Interior Ceiling: Plywood
Structural Problems: poor quality building
Window quality: Very poor. - some Broken
South facing Windows? 1 (0.72 $M^2$)
Wind Shielding and site: none.

**Heating System:**
Furnace: Fuel used: OIL
Other: none
Comments:
Fuel Bill:
Servicing of System? Once a year? Rarely?
Exhaust Fan:

**Problems:**
Drafts: Yes
Cold in Winter? Rented to school. Sometimes cancelled due to excessive cold.
Control of temp:
Freezing Pipes? Yes.

**Previous Work Done:**
Additions: None
Re-Insulation: None
Weatherstripping: None
Repairs: in poor repair

3.7

# R. Can. LEGION.

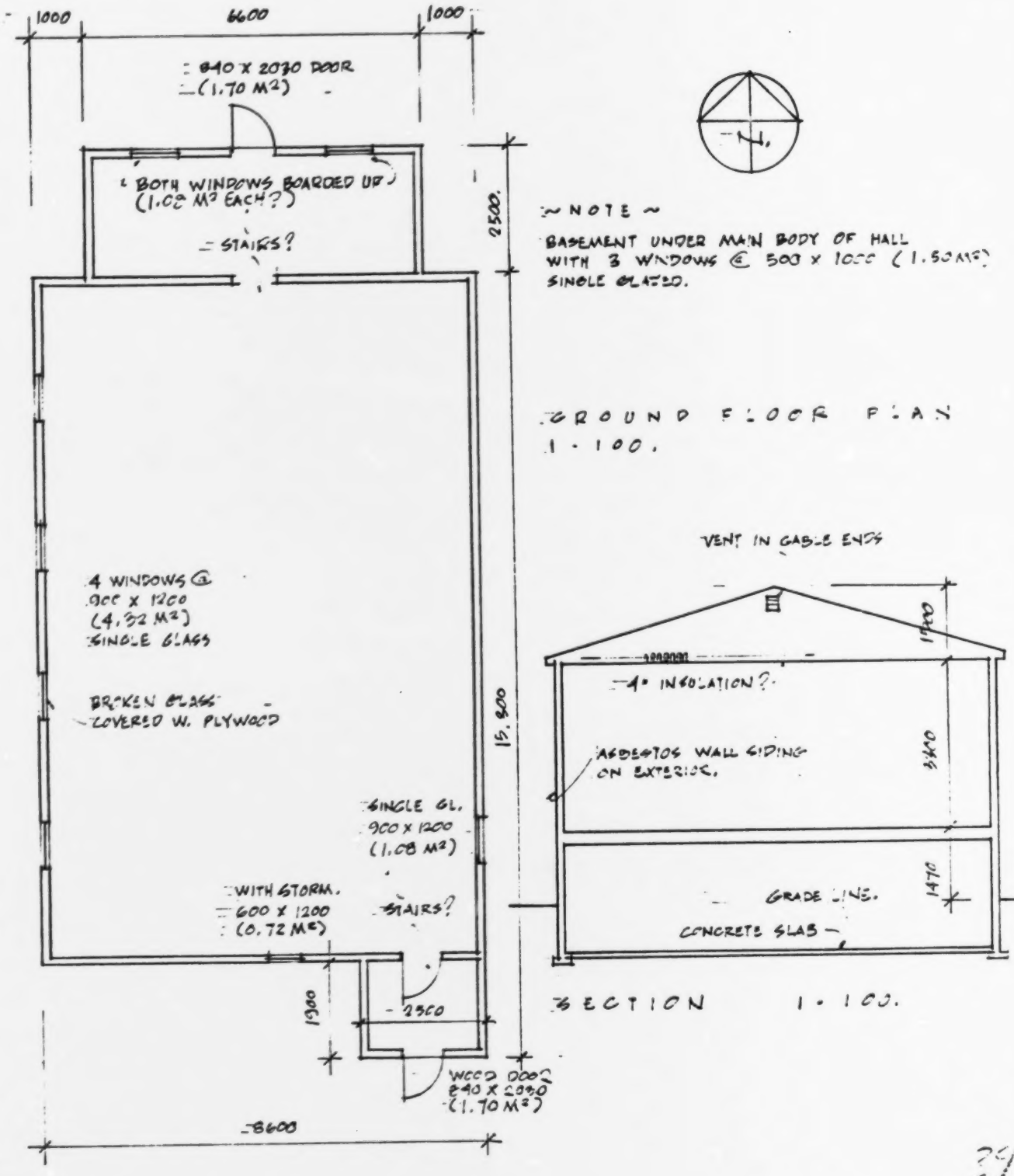

1000
6600
1000
840 x 2030 DOOR
(1.70 M²)
BOTH WINDOWS BOARDED UP
(1.08 M² EACH?)
STAIRS?
2500
~ NOTE ~
BASEMENT UNDER MAIN BODY OF HALL
WITH 3 WINDOWS @ 500 x 1000 (1.50 M²)
SINGLE GLAZED.
GROUND FLOOR PLAN
1 · 100.
4 WINDOWS @
900 x 1200
(4.32 M²)
SINGLE GLASS
BROKEN GLASS
COVERED W. PLYWOOD
15,800
SINGLE GL.
900 x 1200
(1.08 M²)
WITH STORM.
600 x 1200
(0.72 M²)
STAIRS?
1900
2500
WOOD DOOR
840 x 2030
(1.70 M²)
8600
VENT IN GABLE ENDS
1400
4" INSULATION?
ASBESTOS WALL SIDING
ON EXTERIOR.
2400
GRADE LINE.
CONCRETE SLAB
1400
SECTION 1 · 100.

Table of Proposed Changes and Costs

| | | Total Costs |
|---|---|---|
| **1. Furnace Tune-Up** | | |
| Tune-up | $150 | $400 - $1,200 |
| Electric damper | $250 | |
| Retention head burner (not selected) | $800 | |
| **2. Reduce Air Infiltration** | | |
| Fix broken windows<br>Shrink wrap all windows<br>Weatherstrip doors<br>Caulk baseboards<br>Box in exhaust fans | | $1,070 |
| Double glaze windows | | $400 |
| **3. Insulate Roof** | | |
| R 20 fiberglass batts | | $750 |
| **4. Insulate Walls Above Ground Floor** | | |
| (assuming R 12 batts already in place between existing studs)<br>25 mm styrofoam, vapour barrier, removing & replacing panelling | | $975 |
| **5. Insulate Floor Headers and Wood Frame Basement Walls Above Grade** | | |
| Floor headers | $360 | $1,500 |
| R 12 batts to walls, vapour barrier, gyproc | $1,120 | |
| **6. Insulate Basement Walls Below Grade** | | |
| 50 mm styrofoam, wood strapping, vapour barrier, gyproc | | $3,720 |

Results

| Changes | | Predicted Heating Costs | Incremental Heating Savings | Capital Cost of Change | Simple Payback Period |
|---|---|---|---|---|---|
| 0. | Existing Building | $2,760 (1982) | | | |
| 1. | Double Glaze Windows | $2,450 | $310 | $400 | 1.3 years |
| 2. | Furnace Tune-up | $2,290 | $160 | $400 | 2.5 years |
| 3. | Reduce Air Infiltration | $1,875 | $415 | $1,070 | 2.6 years |
| 4. | R11 Upper Basement Walls | $1,050 | $875 | $1,500 | 1.8 years |
| 5. | R20 Roof Insulation | $840 | $210 | $750 | 3.6 years |
| 6. | R6 Upper Walls | $660 | $180 | $975 | 5.4 years |
| 7. | R11 Insulation to Basement Walls Below Grade | $560 | $100 | $3,720 | 37 years |

Recommendations

Because the building is extremely leaky and window quality is poor, installation of double glazed windows is the best measure, primarily to reduce air infiltration. Furnace tune-up and air infiltration improvements are also simple and effective.

Insulation of the building skin, including walls down to grade level, and the roof, (both with lay-in fiberglass batts) is easily done and desirable, with paybacks in the 5 year range.

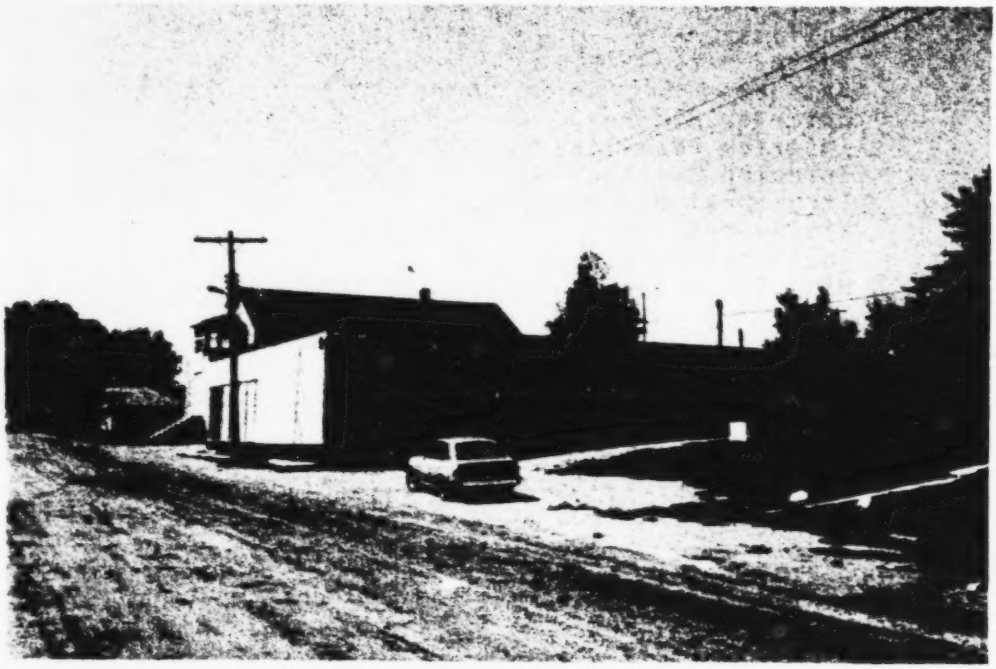
Since the analysis is based on year-round usage of the building, the owners will have to assess whether partial use justifies the costs of the improvements (for example, if the building is only used half of the time, the payback period will double; if it is used one-third of the time, the payback period will triple, and so on). The counter argument is that the suggested improvements will make the building suitable for year-round use (as seems to be the case with the renovations currently being completed), which it was not previously. Therefore, the analysis based on savings from full time occupancy appears to be reasonable.

Taking the first six measures as cost-effective, it can be seen that a 75% reduction in oil use can be achieved at a capital cost of $5,300 $\pm$, with a simple payback of only 2.5 years overall. This is a reflection of the relatively poor condition of the building, and an indication that a comprehensive renovation is required to make it usable.

## 4.34 J & J Hardware

This is a simple one-storey building, with wood frame walls covered by metal siding, and a long span steel joist roof structure. The floor area is 566 $m^2$. The building has few windows, all facing south towards the street. The store appears to be relatively energy-efficient to start with: the floor, walls, and ceiling are insulated; there are few windows for heat loss; and in winter, the owner turns the thermostat back from 20°C during the day to 16°C at night.

The door fan test indicated some points of infiltration: the front door and rear (delivery) door, the ceiling tiles near the roof edge (possibly pointing to a lack of insulation at this juncture), and furnace ductwork, particularly the fresh air intake.



View of the South East Corner

**Remote Community Demonstration Program; Armstrong, Ont.**

**Non Residential Building Survey; Aug.5-10,1983** SURVEY No. 6.1

**Identification:** Owner: Jack Lundstrom. J. & J. HARDWARE STORE
Address: Main St., Armstrong.
Phone:

**Dimensions:** Floor Area $M^2$ Ground: 566 Second: 0 Basement: 0
Heated Volume $M^3$ 2050
Above grade envelope area $M^2$ Walls: 400 Ceiling: 566
Below grade wall envelope area $M^2$ 0

**Construction type and insulation:** $M^2$ and RSI
Year of Construction: 1960's was a Hudson's Bay store (to 19..
No.Stories: 1
Walls: 2"x4" stud, 2" insulation? RSI 1.41.
Floor: Conc Slab
Ceiling: Ceiling tile?
Below Grade: None
Windows; 13.3 $M^2$
Vestibules:
Doors: Solid; 3 Glazed: 2?

**Construction Details:**
Roof: Open web steel joists - FLAT Roof
Soffits: None
Vents: None.
Chimney: metal chimney through roof.
Exterior Siding: Metal siding (alum?)
Interior Panelling: Gyproc
Interior Ceiling: ceiling tile?
Structural Problems: None
Window quality: Good
South facing Windows? Yes - All windows are south
Wind Shielding and site: Good. Low-with Trees behind N. Side

**Heating System:**
Furnace: 415,000 BTU/hr. Fuel used: Oil.
Other: Propane H.W., 1/2" water pipes uninsulated.
Comments: 4 gallons/hr.
Fuel Bill: 3547.98 plus 1 tank of oil $4510/year (1982)
Servicing of System? Once a year? Yes. ~~Rarely?~~
Exhaust Fan: No

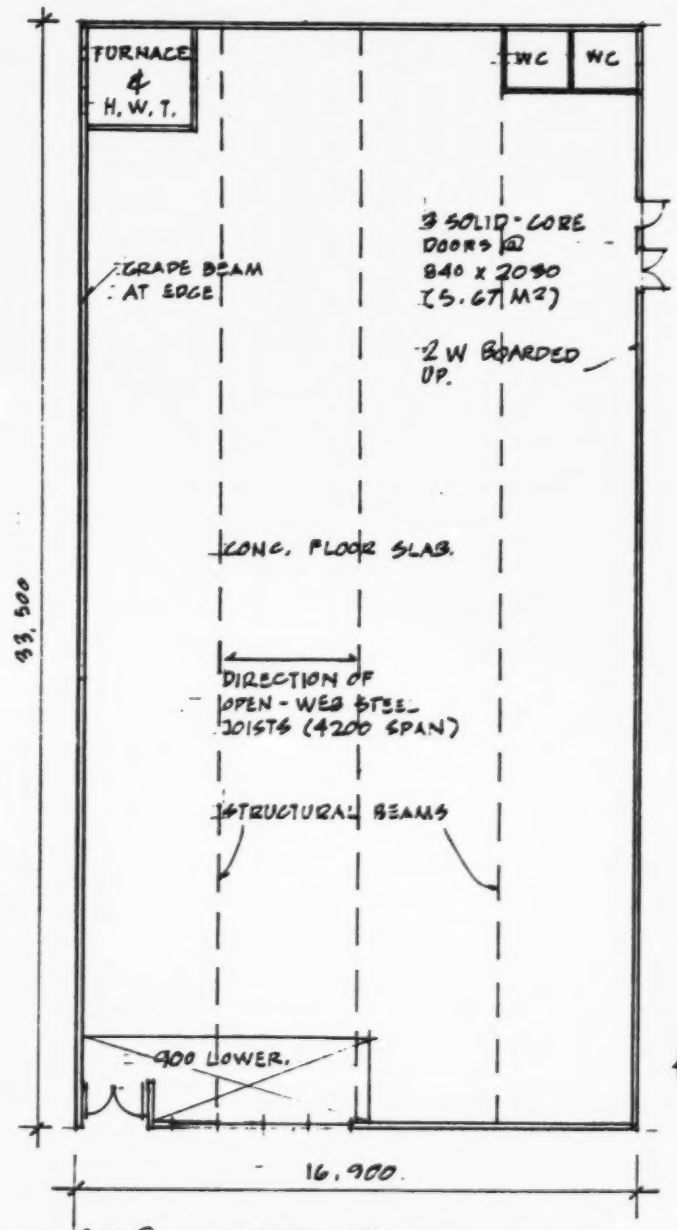
**Problems:** Drafts: No - only if receiving @ rear service door
Cold in Winter? No.
Control of temp: OK.
Freezing Pipes? No

**Previous Work Done:**
Additions: None
Re-Insulation: None.
Weatherstripping: No
Repairs: None

propane Hot Water Tank - (for washroom)

4/

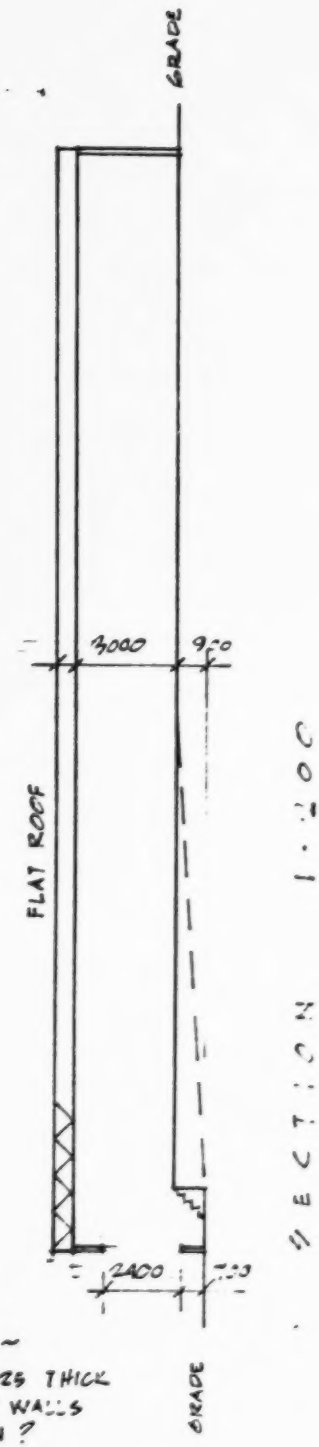
# J. & J. HARDWARE STORE.




20 @ 840 x 2030 (3.78 M²)

WINDOW AREA 2440 x 5440 (13.27 M²)

FLOOR PLAN 1:200.




SECTION 1:200

~ NOTE ~

WALLS ARE 125 THICK
2" x 4" STUD WALLS
2" INSULATION ?
GYPROC INTERIOR
METAL SIDING

Table of Proposed Changes and Costs

| | | Total Costs |
|---|---|---|
| 1. Furnace Tune-Up | | |
| Tune-up | $150 | $300 - $1,100 |
| Electric Control Damper | $150 | |
| Efficient Burner | $800 | |
| 2. Reduce Air Infiltration | | |
| Weatherstrip Doors<br>Shrink wrap windows<br>Caulk baseboards<br>Add vestibules front & rear | | $1,850 |
| 3. Insulate Roof | | |
| Three methods: | | |
| a) 50 mm urethane foamed in place (exterior) + protective coating (R 15) | | $19,600 |
| b) 75 mm styrofoam placed on roof (exterior) (R 15) | | $11,900 |
| c) R 28 batts (interior) + support + vapour barrier | | $7,500 |
| 4. Insulate Walls | | |
| Two methods, using new 2 x 4 stud wall, fiberglass batts: | | |
| a) Interior application (reduces floor area slightly, new interior wall surface) | | $5,050 |
| b) Exterior application, re-uses existing siding, does not disrupt business | | $4,750 |
| 5. Insulated Panels to Windows | | |
| R 10 rigid insulation, framed & covered shutters | | $1,100 |

Results

| Changes | Predicted Heating Costs | Incremental Heating Savings | Capital Costs of Change | Simple Payback Period |
|---|---|---|---|---|
| 0. Existing Building | $4,500 (1982) | | | |
| 1. Furnace Tune-up | $4,200 | $300 | $1,100 | 3.7 years |
| 2. Reduce Air Infiltration | $3,650 | $550 | $1,850 | 3.3 years |
| 3. R28 Roof Insulation | $2,530 | $1,120 | $7,500 | 6.7 years |
| 4. R11 Wall Insulation | $1,825 | $705 | $4,750 - $5,050 | 6.7 to 7.2 years |
| 5. R10 Window Shutters | $1,750 | $75 | $1,100 | 14.7 years |

Recommendations

The simple measures of furnace tune-up and air infiltration reduction are, as in other buildings, among the most desirable energy conservation improvements (payback periods under 5 years). However, because the building is so simple in configuration (box shape, few windows, etc.), it is relatively energy-efficient to begin with, and measures seem to have less effect (i.e. longer paybacks) than with more complex buildings such as the School Board Office.

Roof insulation is desirable if it can be done simply (with batts). The use of rigid insulation on the roof also reduces the heating bill substantially, but the capital cost is so high ($12,000 to $20,000) that the investment is uneconomical.

Wall insulation has a similar effectiveness (6.7 years), particularly the exterior frame option, which re-uses the present exterior siding. Window shutters are less desirable (14.7 year payback) and also take away from the interior retail display.

Taking 6.7 years as the cut-off time for energy conservation improvements, a 60% reduction in oil use can be achieved at a total cost of $14,000 to $15,500. The aggregate payback for these improvements is 5.4 to 5.8 years.

## 5. GENERAL RECOMMENDATIONS

In order to determine whether a building can be economically renovated to conserve energy, we recommend that the following four analysis steps be followed:

1. Collect a full set of data for the building:
   - measurements, photographs, construction (particularly thermal resistance) of major components such as roof, exterior walls, basement, windows
   - historic fuel use records
   - infiltration and furnace tests.

2. Do a component heat loss analysis for the building to determine which building components are the major contributors to heat loss, and therefore, where the greatest reductions in energy use can be achieved.

3. Determine which improvements are feasible within the building construction, cost them, and in general, plan to implement the easiest (and therefore cheapest) changes first, so as not to disruption present operations in the building. Cheaper materials (such as fiberglass batts) are generally preferred to more expensive materials (such as rigid insulation) for the same application.

4. Analyse which changes have the greatest effect on heat loss for the least capital investment, and implement those changes which have the shortest payback periods, up to the limit which the owner feels constitutes an acceptable return, or up to his budget limit.

Based on the results in this project, suggested energy conservation building improvements, in approximate order of priority, are as follows:

1. Furnace tune-up and improvement, if not already done on a regular basis: minor cost, 1 year payback.

   Furnace overhaul: retention head burners, setback thermostats, possible replacement: major cost, 3+ year payback.

2. Air infiltration: this may be as simple as caulking, door weatherstripping, and plugging holes, but double glazing (without insulating shutters) and door vestibules may also be involved: cost variable, 3 year payback.

3. Roof insulation: if it can be economically done with fiberglass batts, and there is sufficient attic space: 5 - 10 year payback

4. Wall insulation: if it can be done with fiberglass batts within the existing wall structure, or an economical means of adding a new structure with the re-use of siding or finishes is possible: 5 - 10 year payback period.

5. Window shutters, basement floor insulation: generally not cost-effective.

# 6. COMMUNITY IMPACTS OF ENERGY CONSERVATION

## 6.1 Energy Savings

The computer analysis indicated very favourable results from the suggested building improvements, and it was considered prudent to allow for a margin of error. Therefore, the savings predicted by the HOTCAN program were reduced for planning and budgeting purposes, as follows:

| | HOTCAN | Conservative |
|---|---|---|
| District School Board Office | 75% reduction | 60% reduction |
| | Oil reduction: 4,900 l | Oil reduction: 3,920 l |
| | Oil Savings: $1,670 | Oil savings: $1,336 |
| | Cap. Cost: $6,655 | Cap. Cost: $6,655 |
| | Payback: 4 years | Payback: 5 years |
| Armstrong Public School | 95% reduction | 60% reduction |
| | Oil reduction: 32,300 l | Oil reduction: 20,700 l |
| | Oil savings: $10,900 | Oil savings: $7,000 |
| | Cap. Cost: $26,000 | Cap. Cost: $26,000 |
| | Payback: 2.4 years | Payback: 3.7 years |
| Royal Canadian Legion | 75% reduction | 60% reduction |
| | Oil reduction: 6,200 l | Oil reduction: 5,000 l |
| | Oil savings $2,100 | Oil savings: $1,700 |
| | Capital Cost: $5,300 | Cap. Cost: $5,300 |
| | Payback: 2.5 years | Payback: 3.2 years |
| J & J Hardware | 60% reduction | 50% reduction |
| | Oil reduction: 8,000 l | Oil reduction: 6,600 l |
| | Oil savings: $2,700 | Oil savings: $2,200 |
| | Cap. Cost: $15,200 | Cap. Cost: $15,200 |
| | Payback: 5.5 years | Payback: 6.9 years |

In general, the higher a building's fuel bills, the larger appear to be the potential energy savings. Complex or leaky buildings, including those with large window areas, appear to be more amenable to energy conservation improvements than simpler buildings such as J & J Hardware. Other important

factors include the age of construction and type of owner. (This latter factor is crucial because some public agencies appear to have ongoing property maintenance and upgrading programs, while other agencies, institutions, and private businesses do not).

In all of the selected case studies, savings conservatively estimated at 60% of present oil use for space heating seem to be possible,, using a cut-off payback period of 5 to 6 years for the improvements implemented. All of these cases include heating system maintenance and adjustments, air sealing, and major additions to the insulation levels of roofs and walls.

The extrapolation of these results to the entire community is difficult, because the four buildings analysed are not necessarily representative of all the non-residential buildings in Town. However, some reasonable approximations can still be made.

The use of oil for space heating reached 1,135,000 litres, or approximately $385,000, in Armstrong in 1982. Of this, one major building complex, D & L Estates, consisting of a number of buildings, accounted for $125,000 alone. The 20 buildings surveyed in this study spend at least $220,000 annually in oil for space heating, from direct examination of their fuel bills. A reasonable approximation for all non-residential buildings (including D & L Estates) in the community would be 65 to 75% of the community's entire fuel oil bill, or about $290,000.

In examining the community-wide impact of building energy conservation measures, a process similar to that followed for selecting buildings for detailed analysis was used: i.e. eliminating well-insulated buildings (with low fuel bills), and those with economically doubtful uses. Still, the buildings which can be renovated probably represent the bulk of this fuel bill, say 80% or $230,000 annually.

Based on the case studies, a conservative estimate of space heating oil costs which could be reduced is 60% of $230,000, or $140,000. This would require owner expenditures of $450,000 (3 year payback) to $700,000 (5+ year payback).

## 6.2 Local Employment

In general, the renovation of a northern building with a basically sound structural shell can be done by local tradesmen or small local contractors, often without the need for detailed planning or design drawings. If larger commercial buildings, or more than 2 to 3 houses at a time are to be retrofitted, outside larger contractors may be able to bid successfully, due to better skills and organization of manpower, in comparison with local tradesmen. Outside firms usually do not hire locals (except possibly labourers) since it is more effective for them to use subtrades with whom they have worked previously. Thus, if local buildings can be upgraded and expanded, instead of building new facilities, then it is more likely that local persons can be employed.

The purchase of building materials locally will increase local business for hardware and lumber supply stores, thus making them more viable and better able to employ staff on a steady basis. If renovation and maintenance activities are done on a regular basis, this may induce local businesses to carry these supplies, and therefore, additional employees. While such a secondary effect might be noticed in a community as large as Armstrong, it would be unlikely to have an effect in smaller centres.

The types of skills required to undertake building renovations are closely related to those required for ongoing building maintenance. Thus, renovations will supply supplemental incomes for tradesmen such as plumbers, electricians, and furnace technicians, and may make full time jobs possible. This is more likely if renovation is carried out in a number of buildings over a long period of time.

Renovation is not as climate-sensitive as new constrruction, since work can be carried on indoors. Therefore, much of the work can be scheduled during winter months, when there is often a scarcity of other jobs in lumbering or tourism.

Many older northern buildings are so poorly insulated and air leaky, that

on cold windy winter days, they become uninhabitable, and the occupants must stop work and return home. This of course, disrupts their employment. An example of this is the Royal Canadian Legion Hall in Armstrong, which was used last winter for adult education, but had to be shut down several times for this reason. If such buildings were properly renovated (as is being done over the 1983 - 84 winter), this kind of disruption would not occur, thus increasing the efficiency and enjoyment of work being done, not to mention the recovery of time which would ordinarily be lost.

Estimates

The local employment component of suggested energy conservation improvements was analysed for each of the case studies, as follows:

| | |
|---|---|
| District School Board Office | Capital Costs: $6,655<br>Local Labour: 220 hours<br>$2,700 (40% of renovation costs) |
| Armstrong Public School | Capital Costs: $26,000<br>Local Labour: 1,000 hours<br>$11,100 (42% of renovation costs)<br>Outside Labour: only required if rigid insulation is applied to the roof. |
| Royal Canadian Legion Hall | Capital Costs: $5,300<br>Local Labour: 275 hours<br>$3,100 (58% of renovation costs) |
| J & J Hardware | Capital Costs: $15,200<br>Local Labour: 475 hours<br>$5,850 (38% of renovation costs). |

These results can be extrapolated to the energy conservation renovation potential for the entire community. Assuming that between $450,000 and $700,000 can be invested effectively in building improvements, it can be seen that a local labour component of approximately 40% will result in an employment expenditure of $180,000 to $280,000, representing 10 to 20 man-years of work, depending on skill and salary levels involved.

## 7. APPLICATION TO OTHER NORTHERN COMMUNITIES

The major difference between Armstrong and most other remote Ontario communities is that it has both rail and road links to larger centres. As a well-established white/native community with several major employers, the non-residential buildings are probably older, larger, and more substantial than similar buildings in smaller communities. Building materials, fuel oil, and skilled labour are also probably cheaper in Armstrong. The non-residential buildings in smaller, more remote communities are probably more akin to large wood frame houses or trailers than those in Armstrong.

However, in examining energy conservation improvements suggested for Armstrong buildings, one notes that they all involve relatively lightweight and common building materials (fiberglass insulation, wood studs, caulking, polyethylene, etc.) which could be brought into most communities relatively cheaply (in comparison with cement, concrete block, fuel oil, etc.). Installation of these materials can generally be done by local labour.

Certain institutional building types (school, medical clinic, police outpost, church, trading post) are probably to be found in one form or another in much of remote Ontario. The potential for energy conservation is likely to depend to a large degree on the owner. Most provincial and federal agency buildings in Armstrong (OPP, MNR, MTC, Post Office) appeared to be in relatively good condition, because of the ongoing maintenance and upgrading programs of those agencies. Some other agencies and private owners had buildings in poorer condition. However, all other things being equal, the economics of energy conservation improvements are likely to be more favourable than in Armstrong because fuel costs with a remote transportation premium are much higher. Unless owners have ongoing maintenance and upgrading programs, or the buildings were constructed in the last few years (say, 1975 or later), such buildings are likely to be energy-inefficient and capable of being retrofitted as described in this report.

The potential for building energy conservation in remote Ontario would appear

to be favourable in some, but not necessarily all instances. Based on just one community, this report indicates that generalizations across building types, owners, and users are probably not possible. An analysis would be required of most candidate buildings in each candidate community in order to determine this potential accurately, together with an assessment of individual factors such as oil prices, building material and labour availabilities in each centre.

The conditions of individual buildings would be important factors in such an analysis, since in many cases, it may be cheaper to replace an energy-inefficient building in poor condition, than to throw good money after bad, by retrofitting it.

APPENDIX A

*ARMSTRONG*

*SUMMARY OF KEY*

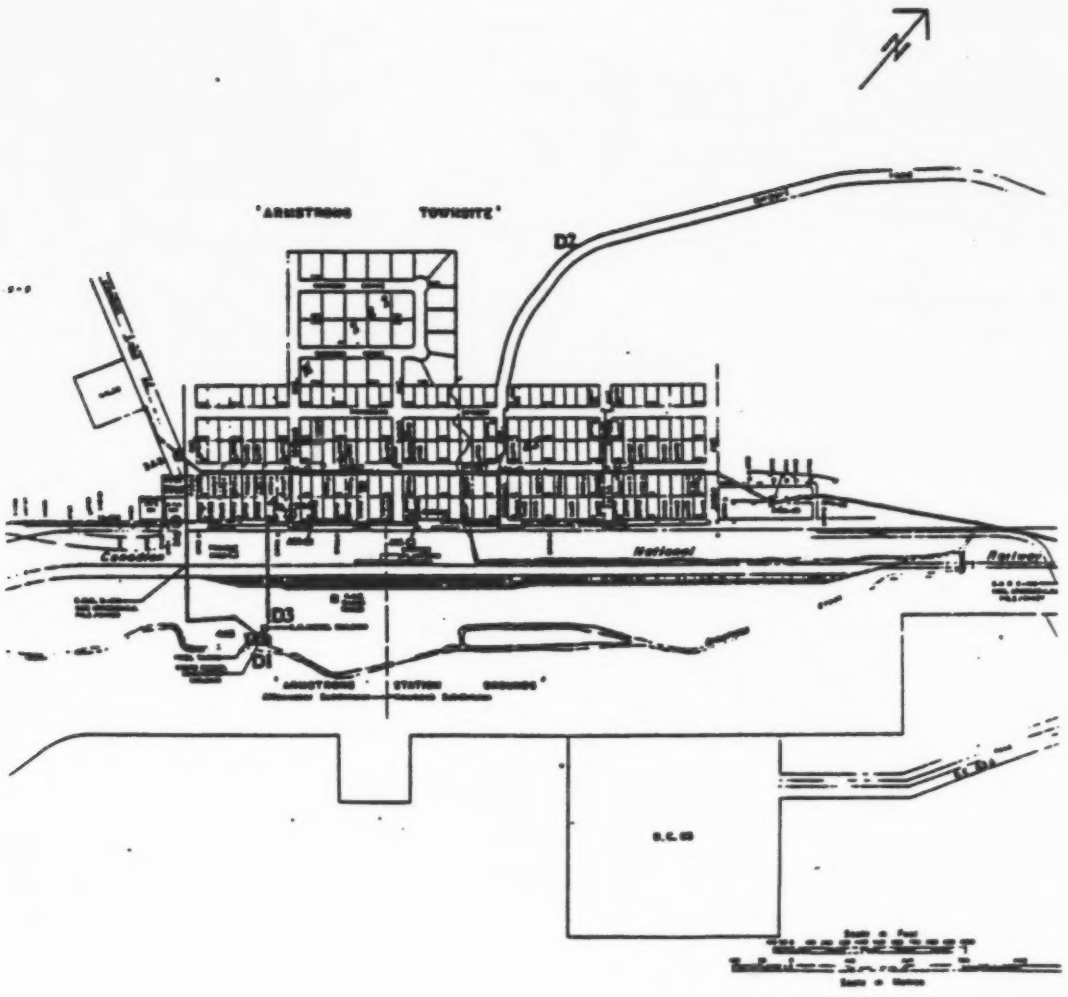
*COMMUNITY ENERGY DATA*

| | | | |
|---|---|---|---|
| 1. | *Status of Community Electrification Program* | 1.1 *Households Currently Serviced* | 126 |
| | | 1.2 *Scheduled Design* | none |
| | | 1.3 *Scheduled Construction* | |
| 2. | *Estimated Peak Power Demand (Current)* | 2.1 *Restricted Service* | 415 kw |
| | | 2.2 *Unrestricted Service* | 415 kw |
| 3. | *Forecasted Peak Power Demand (2000)* | 3.1 *Restricted Service* | N/A |
| | | 3.2 *Unrestricted Service* | N/A |
| 4. | *Renewable Resource Potential* | 4.1 *Hydro* | Poor |
| | | 4.2 *Fuel Wood* | Very Good |
| | | 4.3 *Wind* | Poor |
| | | 4.4 *Solar* | Adequate |

5. *Comments re: Electrification Technology (if any)*

*Primary interest is in securing main grid electricity from Little Jackfish River Project. Not enthusiastic about alternative technologies.*

ARMSTRONG -TOWNSITE



## ARMSTRONG

### DEMOGRAPHIC DATA

1. Location:
   Latitude: 50°18' N Longitude: 89°2' W
   250 km north of Thunder Bay

2. Access:

| | |
|---|---|
| 2.1 Landing Strip | Yes, MTC operated; 2 runways a) 3700 ft., and b) 3200 ft; paved surface; no landing lights; nondirectional beacon -- no scheduled flights |
| 2.2 Seaplane | Yes, 2 charter services -- Huron Outfitters and Air Service and Wawieg Lake Outfitters Ltd. |
| 2.3 Road | Yes, Highway #527, gravel surface. |
| 2.4 Rail | Yes, C.N. |

3. Population — 800 (1982); N/A (2000)
   Approximately 60% white residents and 40% Metis and non-status Indians.

4. Housing

| | |
|---|---|
| 4.1 No. of households | 126 (1982), N/A (2000) |
| 4.2 No. of households served by electricity | 126 (1982) |

4.3 Housing description:

- 25% trailers
- 75% frame construction (1920-40's construction)
- 400-800 sq. ft.
- poorly insulated
- centrally heated; 85% fuel oil; 10% propane; 5% wood
- plumbing; private wells and septic systems
- 100% with electricity
- 100% telephones
- planned community lay-out

Armstrong

4.4 Heating Systems (Primary Source)

Fuel Oil -- 85% of households
75% -- furnace
25% -- space heaters

Propane -- 5-10%
New households in trailer park development
Recent only

Wood -- 5-10%
Increasing use as supplementary source
Majority of wood stoves light sheet metal construction; a small number of high efficiency wood stoves reported to be in use

5. Community Facilities and Services

5.1 Stores and Businesses

- 2 general stores
- 1 liquor store
- 2 service stations
- 2 restaurants
- 1 hotel
- 1 motel
- 2 summer resort lodges
- 1 taxi service

5.2 Schools

- 1 elementary school -- 137 students (Northern District School Board)
- Secondary school students board in Thunder Bay or North Bay

5.3 Churches

- 1 Roman Catholic Mission

5.4 Communications

- 1 Canada Post Office,
  Armstrong, Ontario. POT 1AO

Armstrong

Communications (Cont'd)

- Telephone
  Bell Canada service to virtually all area homes and businesses
- Newspapers
  1 daily from Thunder Bay available regularly
- Radio Stations
  2 AM stations received: CBC Northern Network and CKPR
- Television (via satelite)
  CBC Northern Network and TV Ontario

5.5 Transportation

- Bus Service
  Mrakic Bus Service -- privately owned; daily schedule to and from Thunder Bay
- Railway Service
  CN service -- Tuesday, Thursday and Saturday from West
  -- Monday, Wednesday and Friday from East
- Air Service
  MTC operated airport
  2 runways -- 1 @ 3700'
  -- 1 @ 3200'
  No landing lights
  Paved Surface
  Nondirectional beacon

5.6 Medical and Social Services

- One Nursing Station/Clinic with 1 permanent nurse/receptionist and 1 full time doctor on rotating basis.
- Emergency ambulance service is provided by Ministry of Health in Thunder Bay where a jet helicopter is available.
- Social Services provided periodically by visiting staff; regular services are available in Thunder Bay.

5.7 Other Services

- Fire Protection: Volunteer fire department (10-15 men)
- Police Protection: Ontario Provincial Police
  Armstrong Detachment (6 constables)
- Electricity: Ontario Hydro Diesel Installation
  160 customers
- Roads Service: MTC maintained

Armstrong

5.8 Recreation Facilities

- Outdoor skating rink
- Indoor curling rink (2 sheets natural ice)
- Baseball diamond
- Public library

5.9 Local Service Organizations

- Local Services Board
- Local Roads Board
- Armstrong Development Corporation
- Chamber of Commerce
- Lions Club

6. Local Employment

The major employers are:

- Great West Timber Limited
- Canadian National Railway
- Ministry of Natural Resources
- Ontario Provincial Police
- Northern District School Board
- D & L Estates

7. Heavy Equipment

- A complete range of heavy equipment is available in the Armstrong region.

8. Transportation

8.1 Heavy Equipment

8.1.1 CN freight

8.1.2 Truck

8.2 Freight/Persihables

8.2.1 Bulk Fuel: Propane and premium gasoline via truck from Thunder Bay

Other fuels: Imperial Oil and Gulf Oil via rail from Winnipeg

8.2.2 Perishables/Other Freight: Truck from Tunder Bay

Armstrong

8.3 Passengers: CN passenger service
Bus to and from Thunder Bay
Private car
Charter plane service; no scheduled air service

9. New Developments

Three area of new development were identified: These are.

1. Expanded timber cutting
2. Establishment of a variable length sawmill
3. Access to grid power

Armstrong residents are strongly supportive of a bid by Great West Timber Limited to expand timber cutting operations in the area. Contingent upon provincial approval of this expanded timber cutting, Great West has tentatively agreed to provide road access to several neighboring rail communities including an Armstrong to Collins road as well as a road connecting Allanwater to the existing Savant Lake road. If timber cutting is expanded in the region local residents are optimistic that not only will Armstrong's population likewise expand but also that it will become a regional service center. In addition, Armstrong is seeking to establish a local variable length sawmill operation which would utilize wood (less than 7" radius) not suitable for transporting to Thunder Bay mills.

An alternate land use proposal would see much of the land tract in question, designated as a wilderness park, thus curtailing much of the proposed timber cutting expansion. Residents of Armstrong as well as neighbouring communities are opposed to this proposal. No deadline for resolution of this issue has yet been set.

Armstrong residents are also strongly pursuing a grid connection to the proposed Jackfish River hydro development project currently under consideration. This site is approximately 60 km northeast of Armstrong. Access to grid electricity is considered to be a key element if Armstrong is to realize its economic development goals.

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Armstrong

## COMMUNITY ENERGY PROFILE

### A) Annual Fuel Consumption

Table 3.8 A presents total annual energy consumption by fuel type and end use.

TABLE 3.8 A

ARMSTRONG: ANNUAL FUEL CONSUMPTION

Fuel Type/End Use/Cost

| Fuel Type | End Use Application | Annual Consumption by End Use | Annual Consumption by Fuel Type | On-Site Retail Cost |
|---|---|---|---|---|
| 1. Fuel Oil | . Diesel Generated Electricity* | 998,000 l | | 38.1¢/l |
| | . Space Heating | 1,138,000 l | 2,177,200 l | 31.1¢/l |
| | . Transport/Heavy Equipment | 40,400 l | | |
| 2. Gasoline | . Transportation | 507,000 l | 507,000 l | 47.3¢/l |
| 3. Propane | . Space Heating | 139,400 | 692,000 l | 30¢/l |
| | . Water Heating/Cooking/ Refrigeration | 553,000 | | |
| 4. Kerosene | Minimal Use | | | 55¢/l |
| 5. Wood | . Supplementary Space Heating | 200-400 cords | 200-400 cords | |
| 6. Av Gas | . Light Aircraft | 400,000 l | 400,000 l | 69¢/l |
| | . Charter Services | | | |

*Does not include private diesel uses outside of community power

Visitors Assistance

### B) Installed Diesel Electricity

Armstrong is the only rail community in the study group which has a community electrification program provided by Ontario Hydro. Virtually all of the residences and commercial facilities in Armstrong are serviced by diesel generated electricity. The service provided to residences under Ontario Hydro's community electrification program

is restricted. Restricted residential service means supply through a 20 ampere-240 volt service breaker which effectively limits usage to lighting, television, refrigeration and small appliances. Unrestricted service (no 20 ampere breaker) is provided to commercial facilities. The current rate is:

9.25¢/Kwh -- Restricted Residential Service
29.1¢/Kwh -- Standard Service

Table 3.8 B presents a profile of diesel electricity production by Ontario Hydro in Armstrong. Figures presented are for 1981.

TABLE 3.8 B
DIESEL ELECTRICITY PRODUCTION
ONTARIO HYDRO, ARMSTRONG
1981

| Month | Peak Demand (kw) | Monthly Production (Kwh) |
|---|---|---|
| January | 240 | 132,500 |
| February | 260 | 135,500 |
| March | 230 | 130,000 |
| April | 220 | 121,500 |
| May | 180 | 111,000 |
| June | 180 | 106,000 |
| July | 190 | 120,500 |
| August | 200 | 113,000 |
| September | 220 | 118,500 |
| October | 180 | 125,000 |
| November | 210 | 142,000 |
| December | 230 | 148,000 |

*Source: Ontario Hydro

## Armstrong

In addition to Ontario Hydro's diesel installation, there are several private diesel sets which are operated on a regular basis. Table 3.8 C presents a summary of these diesel installations serving the Armstrong area.

TABLE 3.8 C

ARMSTRONG, ONTARIO 1980

DIESEL GENERATED ELECTRICITY CAPACITY

| Owner | Capacity | Make and Model | Annual Production | Peak Demand | Facilities Served | Annual Fuel Consumption |
|---|---|---|---|---|---|---|
| 1. Ontario Hydro | 200 kw<br>1 standby | Cummin's KTA 1150 | 1,571,<br>953 kwh | 200 kw<br>(Feb.) | 100 customers | 557,000 l |
| 2. Private (9 & L Enterp.) | 175 kw<br>100 kw | Detroit Diesel | 204,000 kwh | 155 kw | . 50 rental cottages<br>. 43 rental units<br>. restaurant<br>. maintenance | 331,400 l |
| 3. Ministry of Transportation and Communication | 75 kw | N/A | N/A | N/A | . Airport<br>. and maintenance | 107,700 l |
| 4. Canadian National Railway | 250 kw | N/A | NIL | NIL | . Back-up for Ontario Hydro facilities only | NIL |

Wardrop Associates

In addition to the diesel installations noted above, it is estimated that within a 15-20 km radius there are approximately 10 private diesel sets in operation during the summer months.

The Ministry of Natural Resources (2 diesel sets, summer base camps) and private tourist camps (8) are the operators of these installations. These diesel sets are assumed to be in the 5-20 kw range and serve only immediate facilities.

## APPENDIX B

### HOTCAN

HOTCAN: A Computer Program for Estimating the Space Heating Requirements of Residences, (National Research Council; Dumont, Lux, Orr, September, 1982)

HOTCAN is a computer program developed for microcomputers by the National Research Council, to estimate the space heating requirements of low-energy houses. The analysis is performed on a month by month basis.

The space heating required for a particular month = heat losses - heat gains.
Heat losses include:

- above grade transmission losses through exterior walls, windows, ceiling, etc.
- infiltration, ventilation
- below-grade heat losses.

Heat gains include:

- internal sources: lights, appliances, people
- solar gains through windows.

The program runs on the NorthStar Advantage microcomputer, supplied by the Toronto Conservation and Renewable Energy Office of Energy, Mines & Resources Canada.

Some modifications and simplifications had to be made to HOTCAN for this application because none of the buildings were energy-efficient to start with, and they often had construction features (for example: slab on grade, no basement) not anticipated by the HOTCAN formulation.

Typical HOTCAN Computer Run

```
* * * * * * * * * * * * * * * * * * * * *
*                  HOTCAN!                *
* NATIONAL RESEARCH COUNCIL OF CANADA     *
*    DIVISION OF BUILDING RESEARCH        *
*    SASKATOON, SASKATCHEWAN, 1982        *
*        (RELEASE HOTCAN 4.01)            *
* * * * * * * * * * * * * * * * * * * * *
```

CLIENT NAME: SWIFT
ADDRESS : ARMSTRONG

USER DATA FILE NAME: BOARDOFF,2

DATA IS FOR SWIFT CURRENT (Solar Radiation Data only - same latitude as Armstrong)

*** BUILDING PARAMETERS ***

| ELEMENTS | HOUSE VOLUME | AIR CHANGE | HT LOSS W/DEGC | % SEASONAL HT LOSS |
|---|---|---|---|---|
| VENTILATION | 630.2 M3 | .55/HR | 106.92 | 38.62 |
| | AREA M2 | RSI VALUE M2-DEGC/W | | |
| CEILING | 186.00 | 6.79 | | |
| TOTAL | 186.00 | 6.79 | 27.39 | 9.89 |
| MAIN WALLS | 119.30 | 3.72 | | |
| | 51.80 | 6.00 | | |
| | 134.10 | 6.00 | | |
| TOTAL | 305.20 | 4.84 | 63.05 | 22.78 |
| DOORS | 3.78 | .36 | | |
| TOTAL | 3.78 | .36 | 10.53 | 3.80 |
| BASEMENT AB.GD | 39.06 | 1.06 | | |
| TOTAL | 39.06 | 1.06 | 36.99 | 13.36 |
| BASEMENT 600MM | .10 | 20.00 | | |
| TOTAL | .10 | 20.00 | .00 | .00 |
| BASE. TO FLOOR | .01 | 20.00 | | |
| TOTAL | .01 | 20.00 | .45 | .11 |
| FLOOR PERIMETER | .01 | 20.00 | | |
| TOTAL | .01 | 20.00 | 1.35 | .34 |
| FLOOR CENTRE | .01 | 20.00 | | |
| TOTAL | .01 | 20.00 | .00 | .00 |
| SOUTH WINDOWS | 3.09 | .54 | | |
| TOTAL | 3.09 | .54 | 5.72 | 2.07 |
| NORTH WINDOWS | 4.13 | .54 | | |
| TOTAL | 4.13 | .54 | 7.65 | 2.76 |
| EAST WINDOWS | 1.59 | .54 | | |
| TOTAL | 1.59 | .54 | 2.94 | 1.06 |

| | | | | |
|---|---|---|---|---|
| WEST WINDOWS | 7.78 | .54 | | |
| TOTAL | 7.78 | .54 | 14.41 | 5.20 |
| S-EAST WINDOWS | .00 | .00 | | |
| TOTAL | .00 | .00 | .00 | .00 |
| S-WEST WINDOWS | .00 | .00 | | |
| TOTAL | .00 | .00 | .00 | .00 |

ADDRESS : ARMSTRONG

DESIGN HEAT LOSS AT -39C = 16.57 KW
DEGREE DAYS FOR SWIFT CURRENT IS 6892
TEMPERATURES (DEG C) MAIN FLOOR = 18 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 3.2
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 14
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 2
MASS LEVEL CHOSEN IS <A>
BASEMENT INSULATED PRIMARILY FROM THE OUTSIDE
WINDOW SHADING COEFFICIENTS: SOUTH = .75 NORTH = .75
EAST = .75 WEST = .75
S-EAST = 0 S-WEST = 0
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.07 M
AVERAGE OVERHANG WIDTH = 0 M
AVERAGE HEIGHT ABOVE WINDOW = .27 M
NATURAL INFILTRATION RATE (AC/HR) = .35
FORCED VENTILATION RATE (AC/HR) = .2

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

| MONTH | THERMAL LOAD KWH/D | MONTHLY SOLAR FRAC | AUX HEAT REQ KWH/D | TOT CONS KWH/D |
|---|---|---|---|---|
| JAN | 239.56 | .07 | 223.66 | 239.66 |
| FEB | 221.11 | .11 | 197.12 | 213.12 |
| MAR | 174.16 | .18 | 143.08 | 159.08 |
| APR | 105.32 | .26 | 77.48 | 93.48 |
| MAY | 54.31 | .50 | 27.28 | 43.28 |
| JUN | 15.18 | .96 | .61 | 16.61 |
| JUL | .00 | 1.00 | .00 | 16.00 |
| AUG | 5.76 | 1.00 | .00 | 16.00 |
| SEP | 42.13 | .50 | 20.92 | 36.92 |
| OCT | 79.87 | .24 | 60.34 | 76.34 |
| NOV | 144.12 | .10 | 129.46 | 145.46 |
| DEC | 211.03 | .06 | 197.79 | 213.79 |

*** YEARLY ENERGY CONSUMPTION COMPARISONS ***

12 MONTH HEATING SEASON IN EFFECT
ANNUAL SOLAR HEATING CONTRIBUTION = 17 %

| | |
|---|---|
| ESTIMATED ANNUAL SPACE HEATING 117 GJ, OR | 32,589 KWHRS |
| SEEH PROGRAM ENERGY BUDGET FOR SPACE HEATING = | 14,290 KWHRS |
| PREDICTED ANNUAL AUXILIARY ENERGY CONSUMPTION = | 5,840 KWHRS |
| SEEH PROGRAM AUXILIARY ENERGY CONSUMPTION = | 10,600 KWHRS |
| TOTAL ANNUAL ENERGY CONSUMPTION = | 38,429 KWHRS |
| TOTAL ANNUAL SEEH PROGRAM ENERGY BUDGET = | 24,890 KWHRS |

*** ANNUAL PREDICTED FUEL COSTS ***

FUEL COSTS ARE FOR ONTARIO AS OF 82/12/01

| ENERGY SOURCE | COST PER UNIT | SPACE HEATING | HOT WATER | LIGHTS AND APPLIANCES |
|---|---|---|---|---|
| OIL | 33.9C/LITRE | $ 1359.79/YR EFF.= 75% | $ 41.53/YR EFF.= 55% | -- |

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This estimate of energy demand may not reflect actual energy requirements of a house due to variations in weather, performance of equipment, and the lifestyle of the occupants.

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APPENDIX C

*NEW LOCATION:*
176 Bronson Avenue K1R 6H4

Retrospectors inc

## Commercial Building Test Results, Armstrong, Ontario

### Legion Hall

#### Fan Test Results

Volume: 721 $m^3$
CGSB Equivalent Leakage Area: 3.38 sg. feet (.313 $m^2$)
Induced Air Change at 50 Pa: 9.7 per hour
Estimated Natural Average Air Change Rate: .925 per hour
Leakage Sites: Throughout the building. Significant leakage through two large exhaust fan systems.

#### Furnace Test Results

Draft: .02" $H_2O$
Smoke No.: 4
$CO_2$: 9%
Stack Temperature: 660° F
Steady State Efficiency: 75%
Comments: Blower compartment panel was not in place.
Filters not in place.
Chimney connector had two barometric dampers, one of which did not have a swinging damper and was located directly adjacent to the combustion air entry to the room from outdoors.
Severe corrosion at base of chimney.

### J and J Department Store

#### Fan Test Results

Volume: 2050 $m^3$
CGSB Equivalent Leakage Area: 3.71 sq. feet (.345 $m^2$)
Induced Air Change at 50 Pa: 4.27 per hour
Estimated Natural Average Air Change Rate: .32 per hour
Leakage Sites: Primarily cracks in ceiling tiles. Also at all doors and penetrations into outer walls.

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Furnace Test Results

Draft: .10" $H_2O$ (normal residential setting: .02 to .04" $H_2O$)
Smoke: No. 8 (normal residential setting No. 2)
$CO_2$: 10%
Stack Temperature: 725°F
Steady State Efficiency: 75%
Comments: Unit is running very dirty. Would probably benefit from cleaning heat exchangers. It may also be overfired (too large a nozzle installed) as the high temperature control in the bonnet regularly turns the unit off. The store employees complain about inadequate heat distribution.

School Board Trailer Office

Fan Test Results

Volume: 454 $m^3$
CGSB Equivalent Leakage Area: 2.13 sq. feet (.20 $m^2$)
Induced Air Change at 50 Pa: 9.06
Estimated Natural Air Change Rate: 1.07
Leakage Sites: Primarily entering through warm and cold air ductwork. Also at joints between trailers at ceiling level, all electrical outlets and switches, all penetrations into floor for telephone and plumbing.